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Studies of the Characteristics of Different Grained Surfaces on Some Typical Lithographic Wipe-On Plates

Porntawee Pungrassamee

STUDIES OF THE CHARACTERISTICS OF DIFFERENT GRAINED SURFACES ON SOME TYPICAL LITHOGRAPHIC WIPE-ON PLATES

by

Porntawee Pungrassamee

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Science in the
School of Printing in the
College of Graphic Arts and Photography
of the Rochester Institute of Technology

June, 1975

Thesis adviser: Dr. Julius L. Silver

School of Printing
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CERTIFICATE OF APPROVAL

MASTER'S THESIS

This is to certify that the Master's Thesis of

Porntawee Pungrassamee

with a major in Printing Technology has been approved by the Thesis Committee as satisfactory for the thesis requirement for the Master of Science degree at the convocation of June, 1975

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STUDIES OF THE CHARACTERISTICS OF DIFFERENT GRAINED SURFACES ON SOME TYPICAL LITHOGRAPHIC WIPE-ON PLATES

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An Abstract

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ABSTRACT

Four different types of grains of wipe-on lithographic plates (mechanical grains, a chemical grain and an electrolytic grain) were studied. The experiments were divided into two parts. The first part concerned surface characteristics of the grained plates, and the second one involved plate performance on a press.

The grained plates' characteristics, including coarseness, gloss, directionality and depth of grain, were examined mechanically, optically and visually. The limitation of each method was discussed. The effects of the surface structures on coating thickness were reported.

The experiments on the press were designed to find which grained plate produced the best printing qualities, such as printing sharpness and resolution. Their tone reproductions were reported graphically. Changes of wettability of the plates during the press run were investigated by contact angle measurements. The factors that caused the change of the contact angles were discussed. The wear of the images on the plates were tested under conditions of increased abrasion.

Most of the data were analyzed by statistical techniques such as analysis of variance and multiple range tests.

Under the experimental conditions, the printing sharpnesses and the tone reproductions of the test plates were alike. The chemically grained plates have higher resolution, compared to the anodized and the sandblasted plates.

The chemical grained and the sandblast grained plates have better image adhesion than do the brush grained and the anodized plates, but their hydrophilic properties change faster than do the latter types.

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CHAPTER I

INTRODUCTION

Lithographic wipe-on plates have been in use for 20 years employing diazonium resins which are the same as those used on some presensitized plates. The aluminum plates, normally, are of very fine grain.[1] (Ball grains are also available but these plates are classified as having a coarse grain.) The special treatment for zinc plates has been developed by the Graphic Arts Technical Foundation[2] but this metal is rarely used in the wipe-on system. The advantages of the aluminum plates are ease in processing, ease in handling on a press, lower cost and fewer problems in storage.

Statement of the Problem

Quality control systems are important in printing reproductions. To set up or maintain the quality of reproductions, materials used in the reproduction process must be investigated.

Printing plates are one of the important materials that have effects on the quality of reproductions. Therefore, their capabilities, printing quality and performance on a press, require study.

Various grained plates for wipe-on process are available. Since their surface structures are different, their effects on printing quality and their performances need investigation. The problem is to determine which type of grain is the best substrate for the wipe-on process. The best substrate refers to performance on the press and printing qualities including printing sharpness, resolution and tone reproduction.

In this study four types of grain were studied. These were chemical grain, brush grain, anodized grain and sandblast grain.

Objectives

The purposes of these experiments are to find the relation of the grained surfaces and their printing quality under equivalent conditions.

If there are significant differences among the printing qualities of the grained plates, printers should select a substrate for the wipe-on process in order to obtain the reproduction they desire. If there are no significant differences in the printing qualities, the printers may choose the grained plates for minimum cost without concern about the quality of reproduction.

FOOTNOTES FOR CHAPTER I

[1] Gyan P. Maden, "A Detail Report on Wipe-on Litho Plates," Printing Production, April 1961, p. 48.

[2] Robert F. Reed, Offset Lithographic Platemaking (Pittsburgh: Graphic Arts Technical Foundation, Inc., 1967), p. 75.

CHAPTER II

REVIEW OF THE LITERATURE

Surface Characteristics of Grained Lithographic Plates

At the present time, there is no generally accepted technique for measuring the amount of roughening of grained surfaces although a number of methods have been developed by researchers. The following were recently reviewed by Powers.[1]

Elton and McDougall adopted the method for measuring the specific surface areas of pulp used in papermaking to measure ball grained and abrasive-blasted grained zinc and aluminum plates.[2] It involved exposing a silver coated plastic replica of the metal surface to hydrogen peroxide. The decomposition rate of the hydrogen peroxide was considered a direct function of the surface area of silver exposed and was measured. This technique was called Peroxide Decomposition.

Another technique, called the Cooling Method, involved the surface area measurement considered to be a function of heat transfer rate.[3] These investigators also employed another technique involving specific volume measurements.[4] The specific volume was defined as the volume of metal per unit of superficial area contained in a smooth plate minus that contained in a rough plate of the same thickness. The smooth one was measured directly and the rough one was measured by a liquid displacement method.

Sheridan used depth of grain to classify roughness of grain.[5] A surface light microscope at 100 magnification and an electron microscope were used to measure the depths of grain.

The Sheffield Lithotest Instrument is a system of air gauges designed for precise dimensional measurements. The techniques were developed for measuring the smoothness of paper and grained lithographic plates.[6] The tests measure the air leakage between smooth metal rings and the surface of a sample.

The author, Powers, suggested a new procedure and an apparatus for measuring the surface area of grained aluminum lithographic plates. The test involved barrier layer anodizing in a tartaric acid electrolyte following certain pretreatment steps. The increase in surface area due to graining was related to the ampere-second used to form the non-porous anodic oxide.

Zelley suggested various methods for studying surface characteristics of grained surfaces including (1) microscopic examinations, (2) surface analysis by the electron microprobe and x-ray fluorescence analysis to detect silicone content in plate surfaces resulting from embedded abrasive, (3) optical measurements at 85 degree gloss and total reflection density, (4) gas absorption analysis for measuring surface areas of grained plates.[7]

Wettability and Contact Angles of Lithographic Plates

The generally accepted technique for measuring the wettability of lithographic metal plates is the contact angle measurement. It has been used for two purposes: studying the hydrophilic property of the metals and detecting residual film left on plate surfaces.

The most widely recognized research work on the wettability of metal plates was done by R. A. C. Adams of PATRA.[8] He measured the interfacial contact angles (see Appendix A) of a drop of oleic acid applied to the metal previously immersed in water. This experiment showed the tendency of a greasy material to displace water from the surface of the metals. Low contact angle indicates that the metal is easily wet with oil, therefore, it is good for making an image area in a multimetal plate system.

In 1949, Hartsuch of GATF used the contact angle measurement technique to study residual film on lithographic printing plates.[9] In the same year, Martin used the same technique to study the wettability of metal plates for albumin and deep-etch processes.[10] His work involved the effect of drying time and chemical treatment on contact angle measurements.

In 1961, Schaffer et al. studied the mechanism of lithographic scumming by a monomolecular film transfer.[11] The contact angle measurements were used to detect the monomolecular layer deposited on the non-image areas. They stated that the contact angle of a rough surface was higher than that of the smooth surface when other conditions were equal. This statement is contrary to that of Davies and Rideal;

> "If the smooth materials give an angle greater than 90 degrees, roughness increases this angle still further, but if θ (contact angle) is less than 90 degrees, roughness decreases the angle."[12]

The studies on wettability of aluminum grained plates were reported by Sugiyama et al.[13] Their investigations included brush grain, ball grain, sandblast grain and anodized grain. The results were (1) the contact angle did not depend on the roughness of the grained surface but it did on the graining procedure, (2) counter-etching with sodium hydroxide reduced the contact angle but counter-etching with sulfuric acid did not influence it, (3) the presensitized plate from which the light sensitive layer was removed had better wettability than the other plates, (4) there was no significant relation between the contact angle and the grained surface roughness.

FOOTNOTES FOR CHAPTER II

[1]John H. Powers, "Surface Area Measuring Test for Grained Aluminum Lithographic Plates," TAGA Proceedings, 1974, pp. 23, 24, 26.

[2]Ibid., p. 24. [3]Ibid. [4]Ibid. [5]Ibid.

[6]Ibid., pp. 23, 26.

[7]W. G. Zelley, "Surface Characteristics of Ball Grained and Brush Grained Aluminum Lithographic Plates," TAGA Proceedings, 1972, pp. 263-270.

[8]Paul J. Hartsuch, Chemistry of Lithography (Pittsburgh: Graphic Arts Technical Foundation, Inc., 1961), p. 179.

[9]Idem, "Residual Film on Lithographic Plates and Methods for Their Removal," TAGA Proceedings, 1949, pp. 25-31.

[10]George N. Martin, "Wettability and the Lithographic Properties of the Metals," TAGA Proceedings, 1949, pp. 38-43.

[11]W. D. Schaeffer, C. Y. Kuo, and A. C. Zettlemoyer, "Monomolecular Film Transfer as Applied to Lithographic Scumming," in Advance in Printing Science and Technology vol. 2: Problems in High Speed Printing, ed. W. H. Banks (New York: Pergamon Press, 1962), pp. 247-265.

[12]J. T. Davies and E. K. Rideal, Interfacial Phenomena 2nd ed. (New York: Academic Press Inc., 1963), p. 37.

[13]Yasuo Sugiyama, Shinichi Habu, and Yoshimitsu Tsunoda, "Studies on Wettability of Aluminum Lithographic Plates," Bulletin of TAGA Japan, January 1971, p. 119. (Only conclusions written in English).

CHAPTER III

DESIGN OF THE EXPERIMENT

The experiments were designed such that all the factors, except the one to be tested, were controlled to obtain equivalent conditions. Most of the experiments were repeated to determine the consistency of the results and also for the requirements of statistical analysis.

Experimental Procedures

Microscopic Examination

The grained surfaces were examined by microscope at 40, 100 and 400 magnifications. The photomicrographs of the grained surfaces were taken at 150 and 400 magnifications.

Coarseness of the Grained Surfaces

The Sheffield Smoothchek (see Appendix I) was calibrated according to the manufacturer's procedure. Twelve measurements were taken at different positions on each plate. The pattern of measurement is shown in Figure 1. The samples were randomly selected to be measured. Two plates of each grain type were tested.

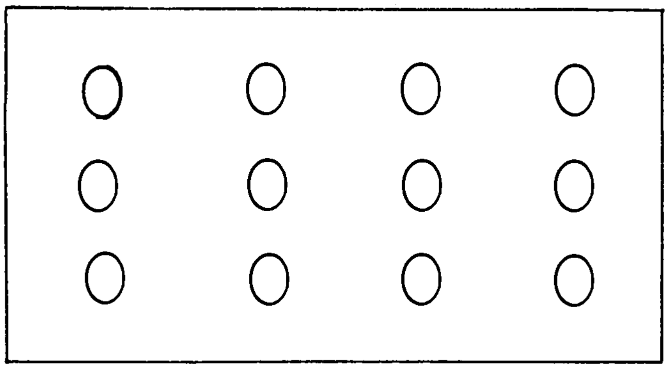


Figure 1. Coarseness Measurements Pattern

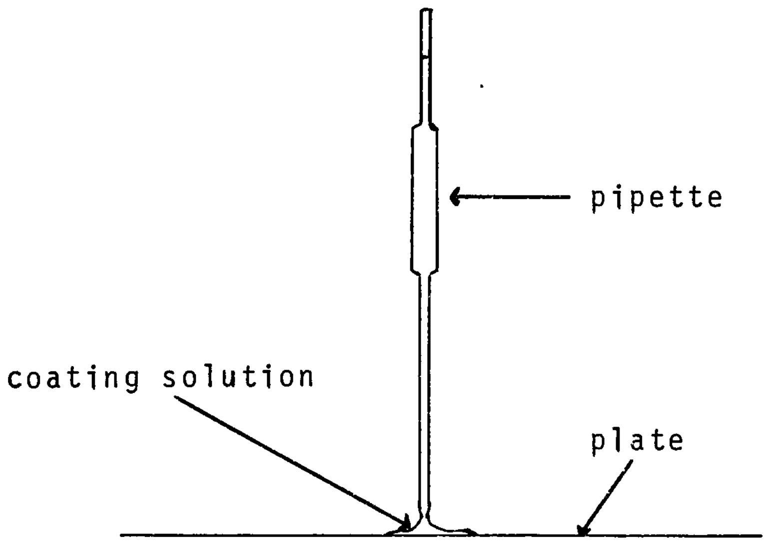


Figure 2. Plate Coating by Whirler

Gloss Measurement at 70 Degrees

The glossiness of the grained surfaces were measured by the Vanceometer (see Appendix I) which was calibrated with the manufacturer's standard plate. Two readings were taken from each sample. The samples were turned 90 degrees before the second measurements were done. Four samples of each grain and each source were tested.

Coating Thickness

The test plates were cut to six by six inch sizes, which is the maximum size for the analytical balance available in the laboratory in order to minimize the error of plate area due to the cutting operations. The sensitizing solution was mixed using the diazonium resin and the solvent at a ratio of 1 gram : 25 cc.

The test plates were placed at the center of whirlers whose speeds were set at 120 rpm. They were flushed with the same amounts of water, at the same temperature, and allowed to whirl for 30 seconds to remove the excess water (see Appendix B). Two cc. of the coating solution were applied to each plate by a pipette. The rate of pouring was controlled by means of a pipette. The pipette was placed close to the plate in such a way that the solution flowed continuously from it to the plate until the last drop (see Figure 2). After being coated, the plates whirled until dry for five to six minutes without heat or a fan. At that time they were dry to the touch. The coated plates were then dried by a fan for 10 minutes and kept at room temperature for about 24 hours before weighing. The samples were randomly tested. They were weighed (before and after coating) using an analytical balance.

Printing Quality Measurements

Arrangement of the Test Objects

Five solid patches were placed across the press direction at the leading edge. Thirty-seven per cent negative tints were placed parallel to the solids. Both of them were used to control ink densities, ink distribution and ink-water balance. If there was too little ink or too much water the density of the solid would be low. If there was too much ink or too little water, the tints would fill in. Below them were the RIT Alphanumeric Resolution Test Target, the GATF Star Target, the GATF Dot Gain and Slur Bar. These targets provided resolution measurements as well as press condition indicators. The continuous tone Kodak T-14 scale and the halftone Bychrom Scale were used to control exposure time and development and for studying tone reproduction curves.

Preparation of Printing Plates

The plates were coated with the same procedure used in the coating measurements, except that the amount of solution was 5 cc. instead of 2 cc. The plates were exposed to a carbon arc lamp to obtain the solid step #6 of the Kodak T-14 scale. After being developed, the plates were gummed with asphaltum gum.

Adjustment of the Press

The small press, Chief 15, was adjusted with a presensitized plate packed to 0.012 inches. The pressure between ink form rollers and the plate was adjusted so that the width of bands of ink which the rollers left on the plate were about 1/8 to 3/16 inches.[1] The squeeze between the plate and the blanket was adjusted in the same way.

Since the plates had different thicknesses, they were packed with packing sheets to 0.011 $\pm$ 0.001 inches (the anodized plates were not packed since their thickness was 0.012 inches). This packing technique eliminated press readjustment when the plates were changed.

Two plates of each grain type were run on the press in series: anodized plates, chemically grained plates, brush grained plates and sandblast grained plates. The second set was the reverse of the first set.

The press sheets were collected consecutively when the densities of the solid patches reached 1.40 $\pm$ 0.05 (wet measurement). The $\pm$ 0.05 variation of density range is generally accepted in the printing industry.[2]

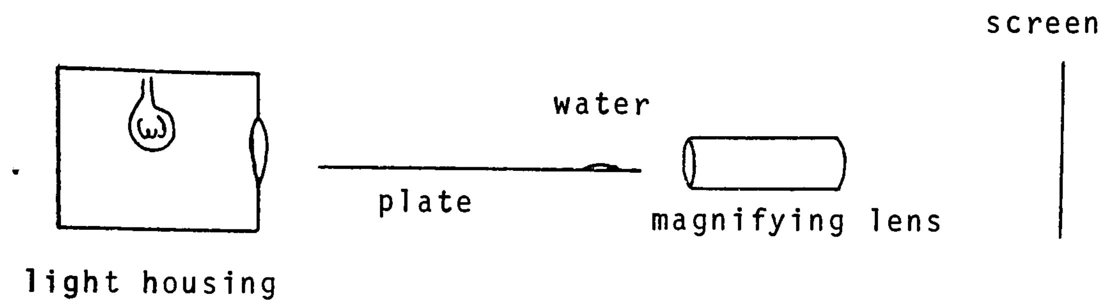
Contact Angle Measurements

The contact angle measurements were taken before the plates were coated, after 1,000 impressions and every 500 impressions thereafter. Two sets of plates were tested under different conditions. The first set was run with higher ink density and lower speed, and the contact angles were measured at the very edges of the plates (see Figure 4). For the second set, (run with lower ink density and higher speed), the contact angles were measured inside the image boundaries. (During the experiment it was observed that the rates of the change of the contact angles was different at different positions of the plates.)

The size of drops of water was controlled by using a syringe. The test plates were run without paper for 10 revolutions before they were taken off the press. They were dried for 15 minutes before the measurements were taken from each plate.

Image Adhesion

Four types of grained plates were run on the press. The blanket cylinder was packed with a piece of plastic sheet to make the plates wear faster than under the usual conditions.[3] The plates were frequently taken off the press and examined with the microscope. The press was stopped when the image showed deterioration.



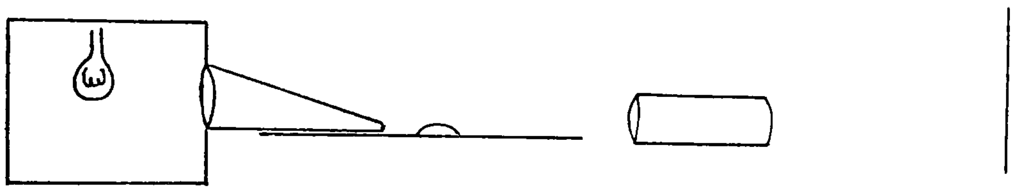


Figure 3. Diagrams of the Apparatus for Measuring Contact Angles.

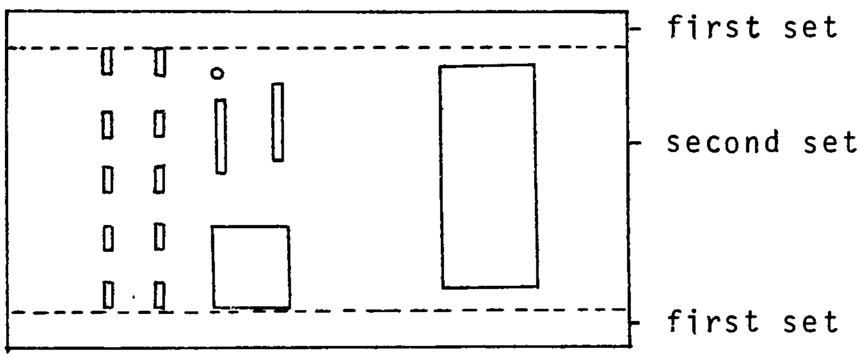


Figure 4. Areas for Contact Angle Measurements

Hypotheses

The best substrate for wipe-on lithographic plates is the one with:

1. best wettability
2. best set of images
3. best resolution

Since the lithographic printing process depends on the selectivity of the image areas and the non-image areas, the wettability of the plate is considered the criterion of the plate performance on the press. The wettability is measured by the contact angle measurements.

The best set of images was measured by the abrasion test on the press.

The best resolution was measured from the printed resolution targets on the press sheets.

FOOTNOTES FOR CHAPTER III

[1]Charles W. Latham, Advanced Pressmanship (Sheet-Fed Press) (Pittsburgh: Graphic Arts Technical Foundation, Inc., 1963, p. 235.

[2]Albert D. Rickmers, "Statistical Quality Control Application in the Graphic Arts," Graphic Arts Progress, March 1971, p. 3.

[3]Latham, Advanced Pressmanship (Sheet-Fed Press), p. 235.

CHAPTER IV

RESULTS AND ANALYSIS OF DATA

Surface Characteristics of Grained Aluminum Plates

Microscopic Examination

The photomicrographs of grained plates, 150 and 400 magnifications, are shown in Figures 5 through 16. They show the difference of grain structures produced by various graining procedures. The brush grained plates, obtained from two manufacturers, have different appearances in the photomicrographs (see Figure 5 and Figure 6, Figure 11 and Figure 12). The difference between anodized plates obtained from different sources can be seen in 400X photomicrographs (Figure 15 and Figure 16).

The presence or absence of directionality of grain can be seen at low magnifications of 40 and 100, but it is not clear in the photomicrographs. The brush grained plates and anodized plates have directionality of grain, but the chemically grained and sandblast grained plates do not.

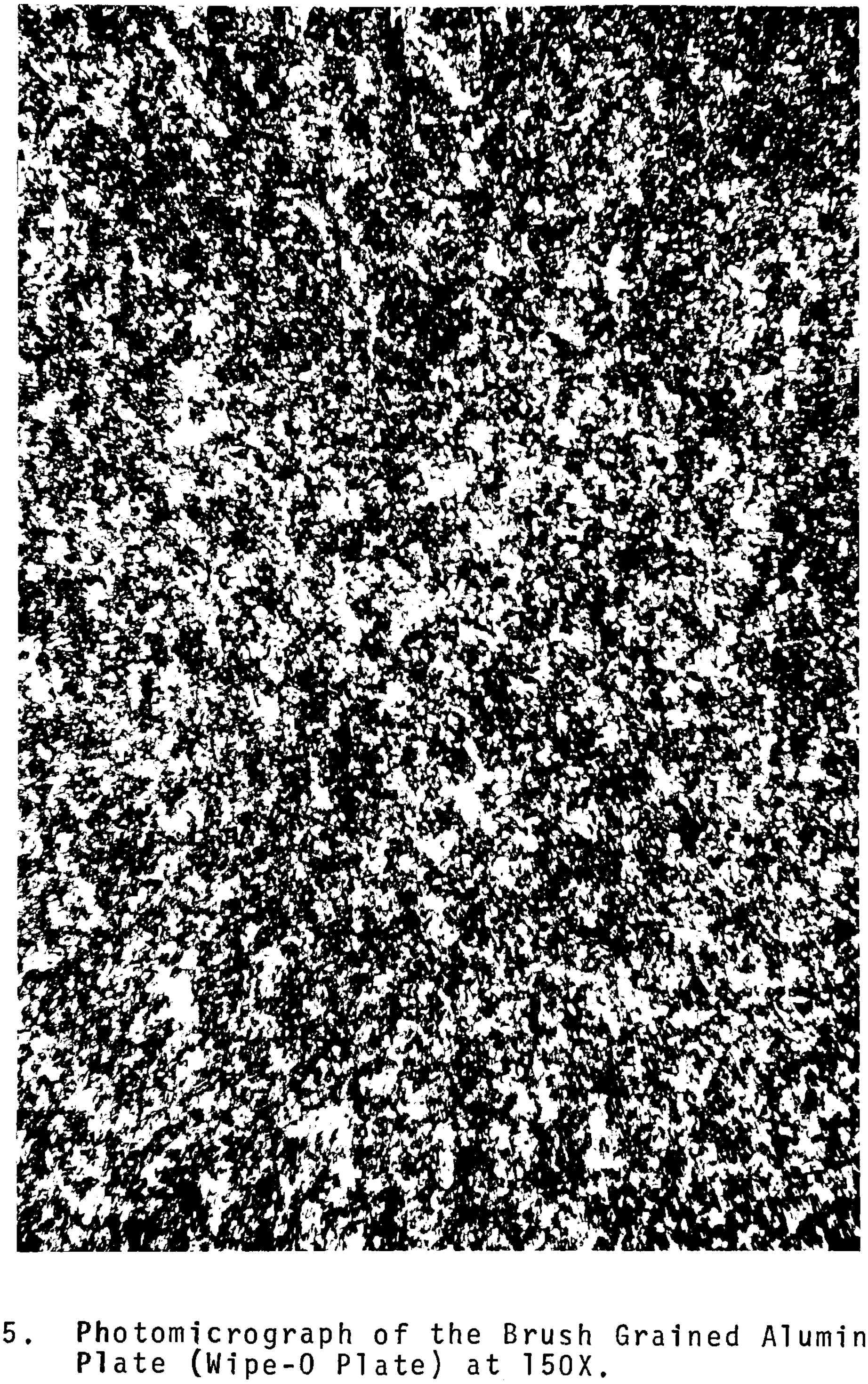


Figure 5. Photomicrograph of the Brush Grained Aluminum Plate (Wipe-O Plate) at 150X.

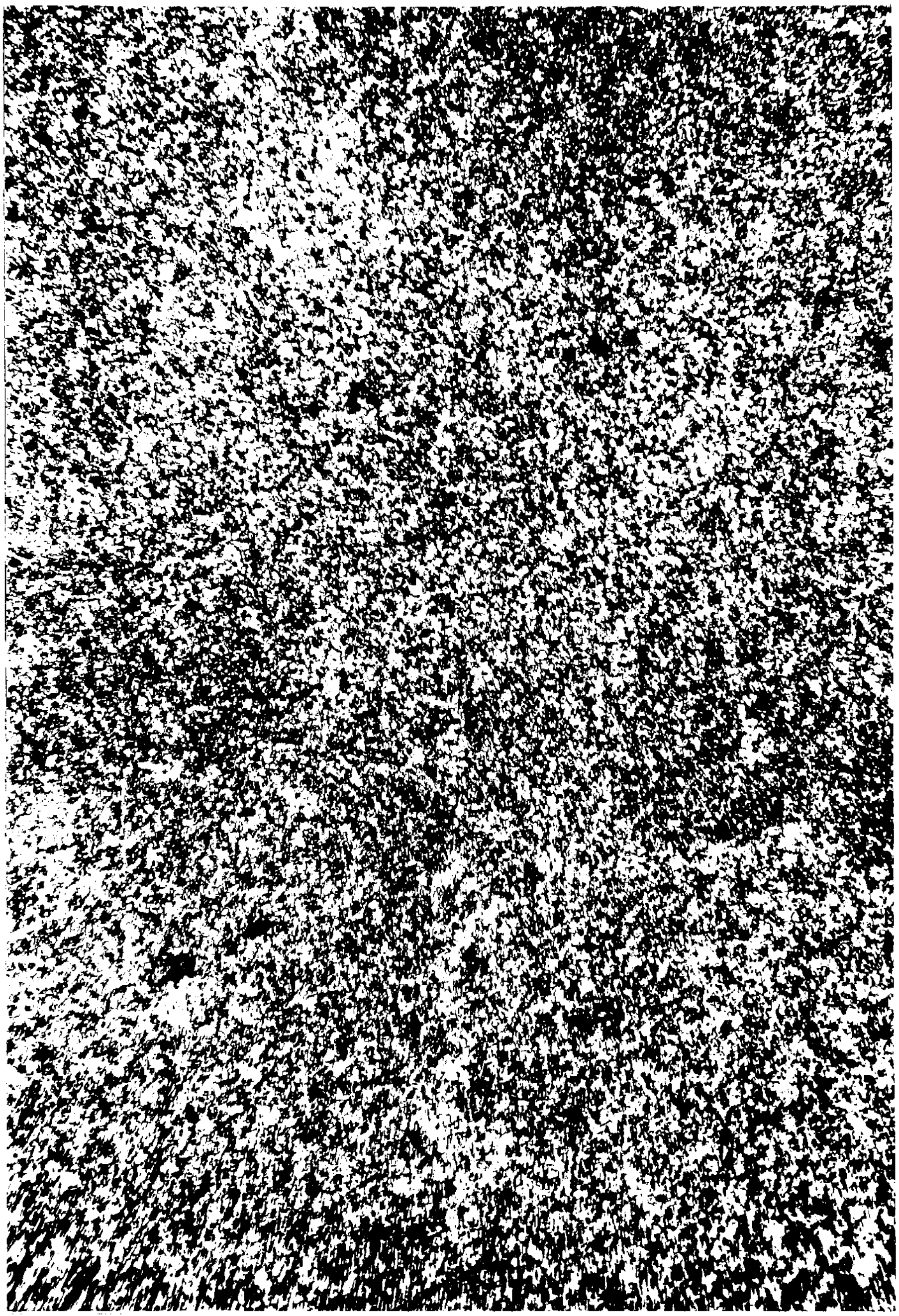


Figure 6. Photomicrograph of the Brush Grained Aluminum Plate (Azoplate) at 150X.

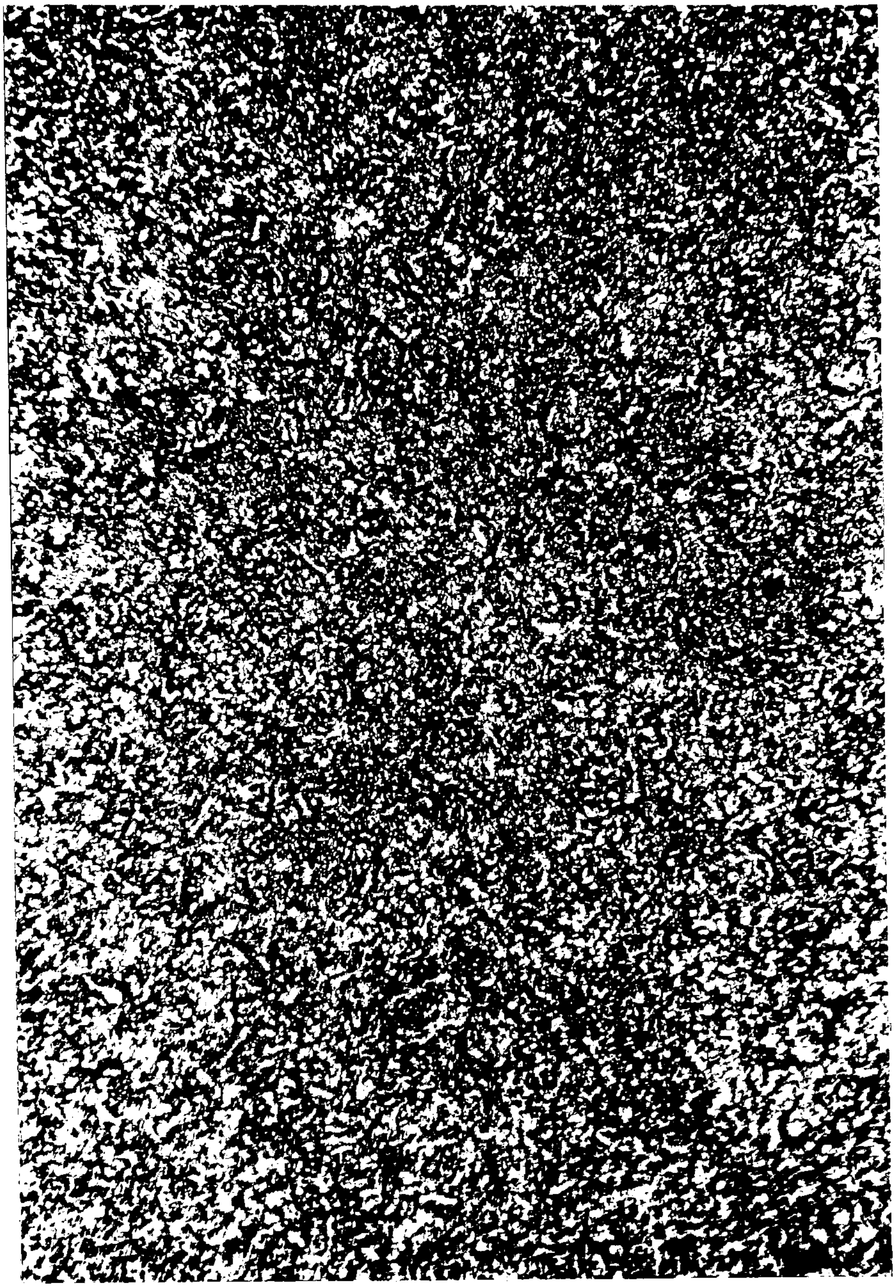


Figure 7. Photomicrograph of the Chemically Grained Aluminum Plate (Granite Grain) at 150X.

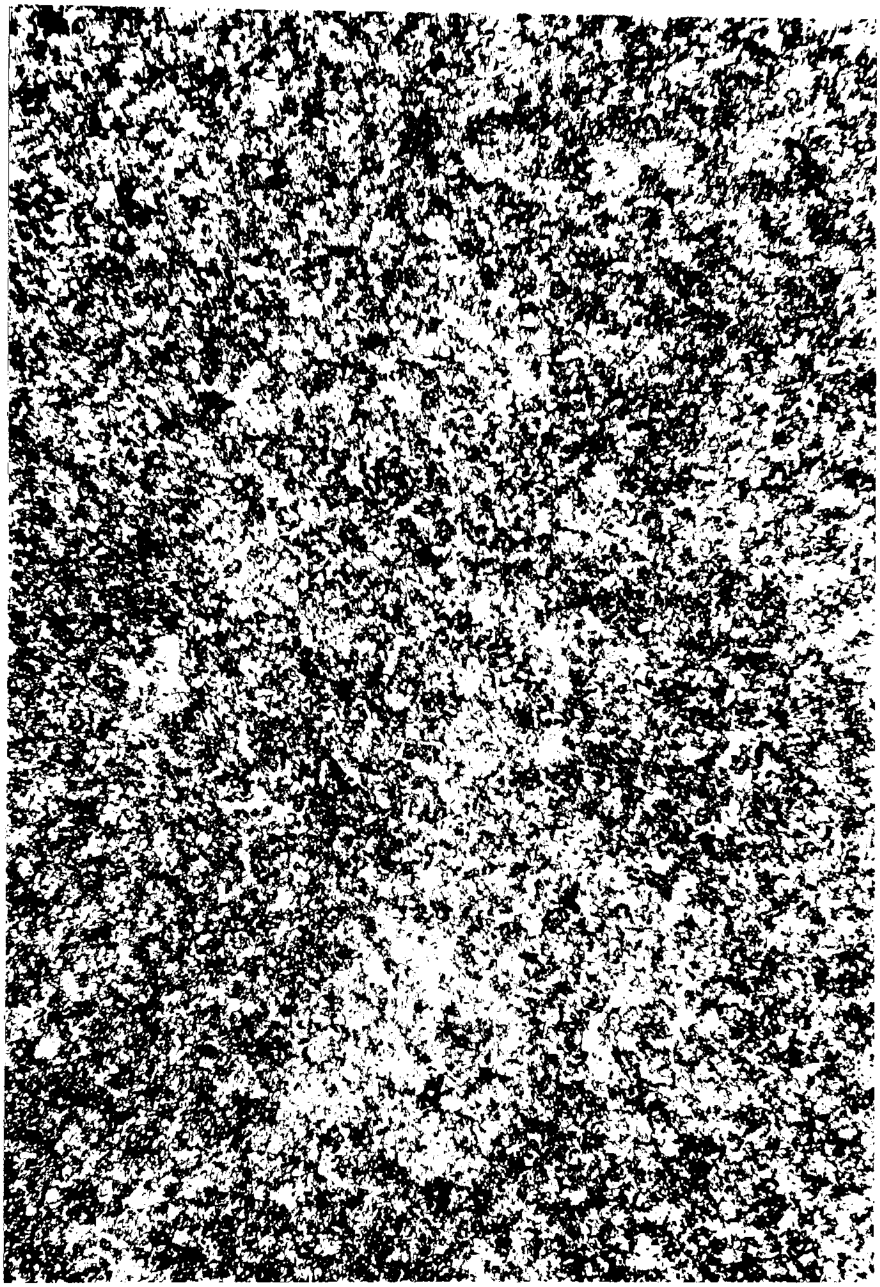


Figure 8, Photomicrograph of the Sandblast Grained Aluminum Plate (ST Plate) at 150X.

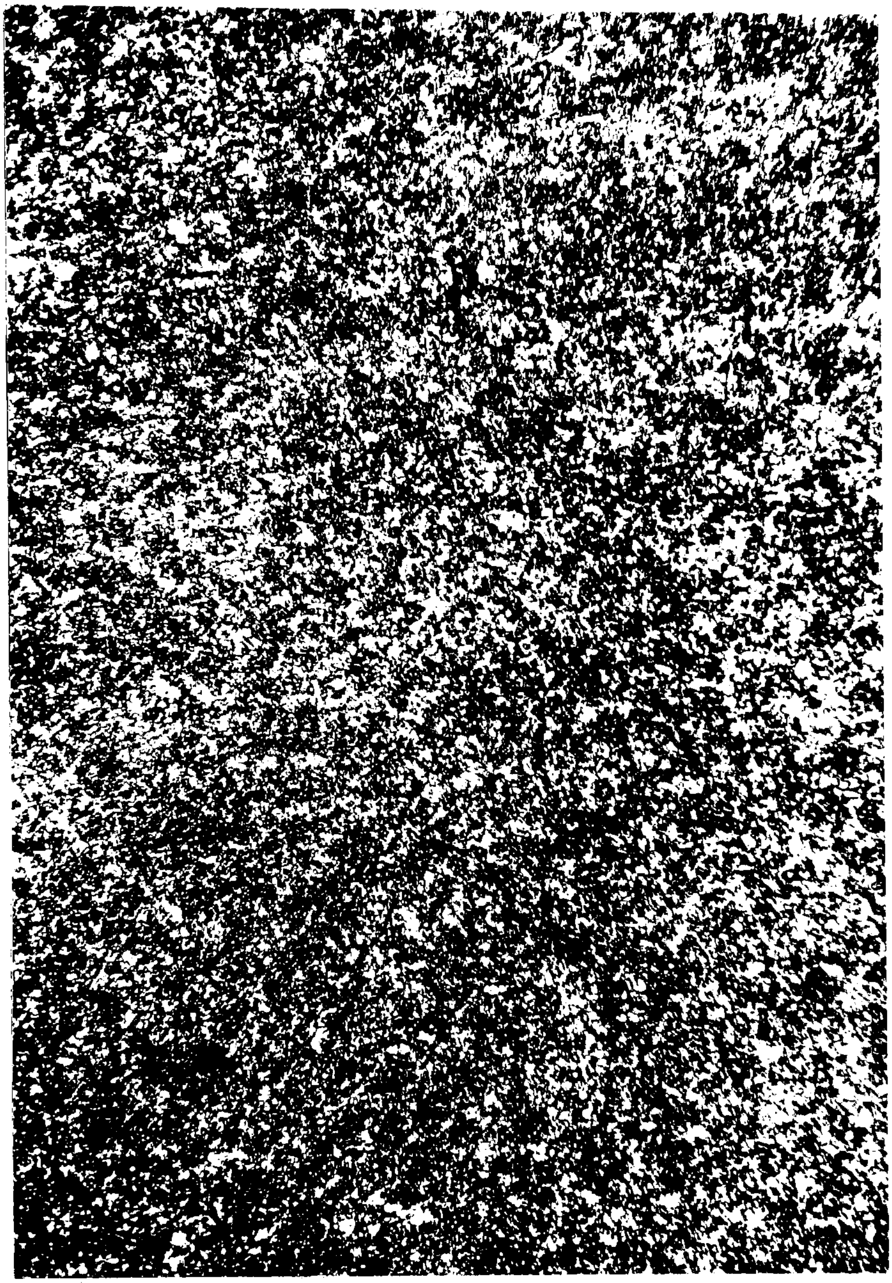


Figure 10. Photomicrograph of the Anodized Aluminum Plate (John Stark S-31) at 150X.

Figure 11. Photomicrograph of the Brush Grained Aluminum Plate (Wipe-O Plate) at 400X.

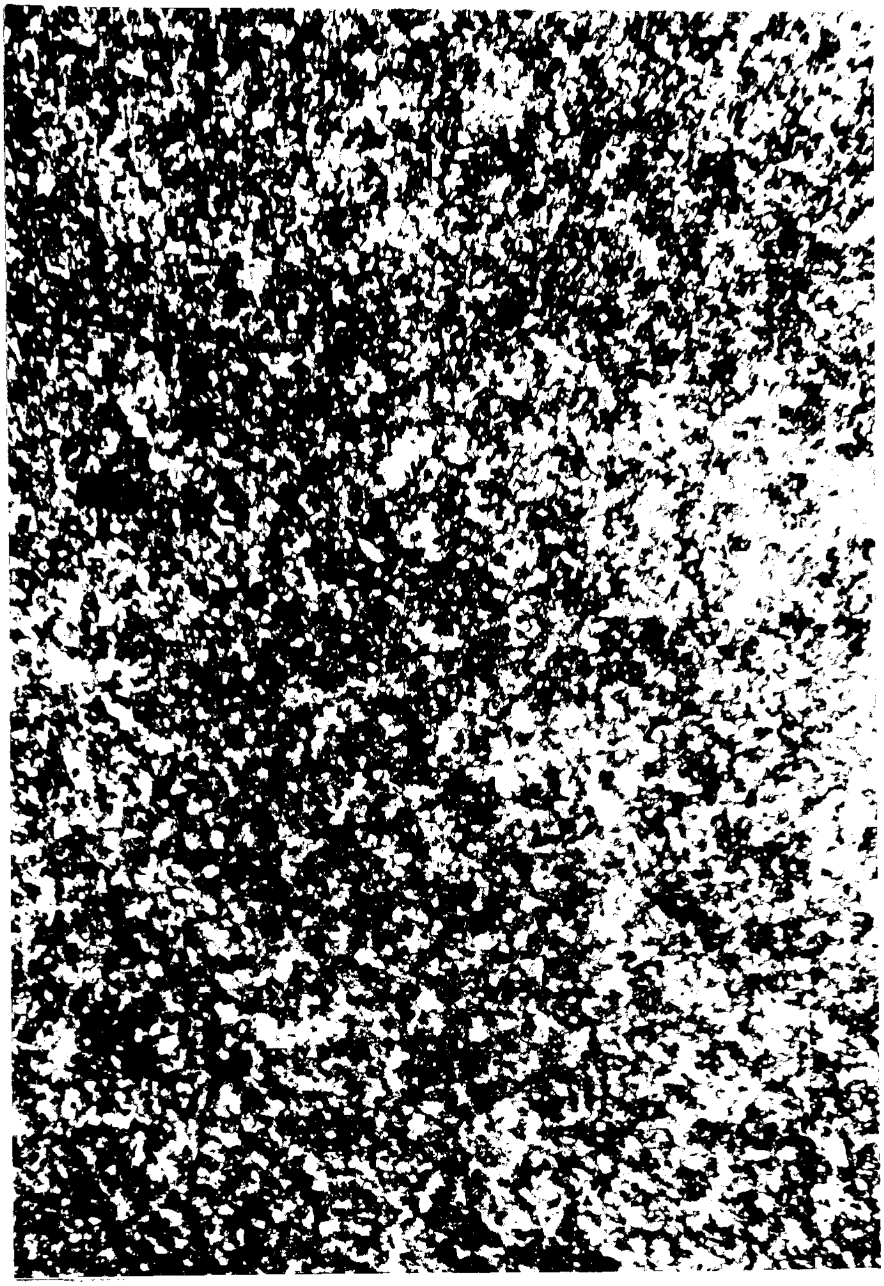


Figure 12. Photomicrograph of the Brush Grained Aluminum Plate (Azoplate) at 400X.

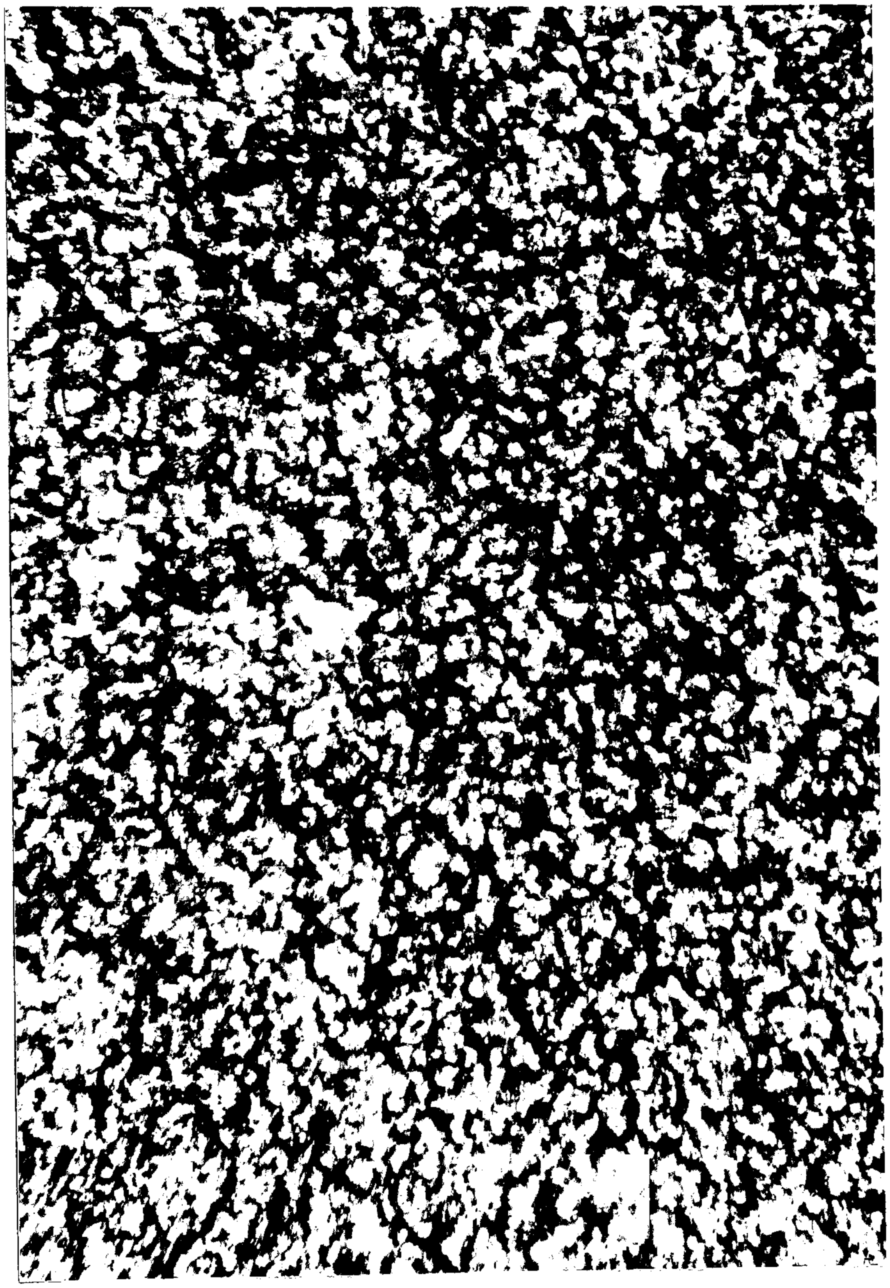


Figure 13. Photomicrograph of the Chemically Grained Aluminum Plate (Granite Grain) at 400X.

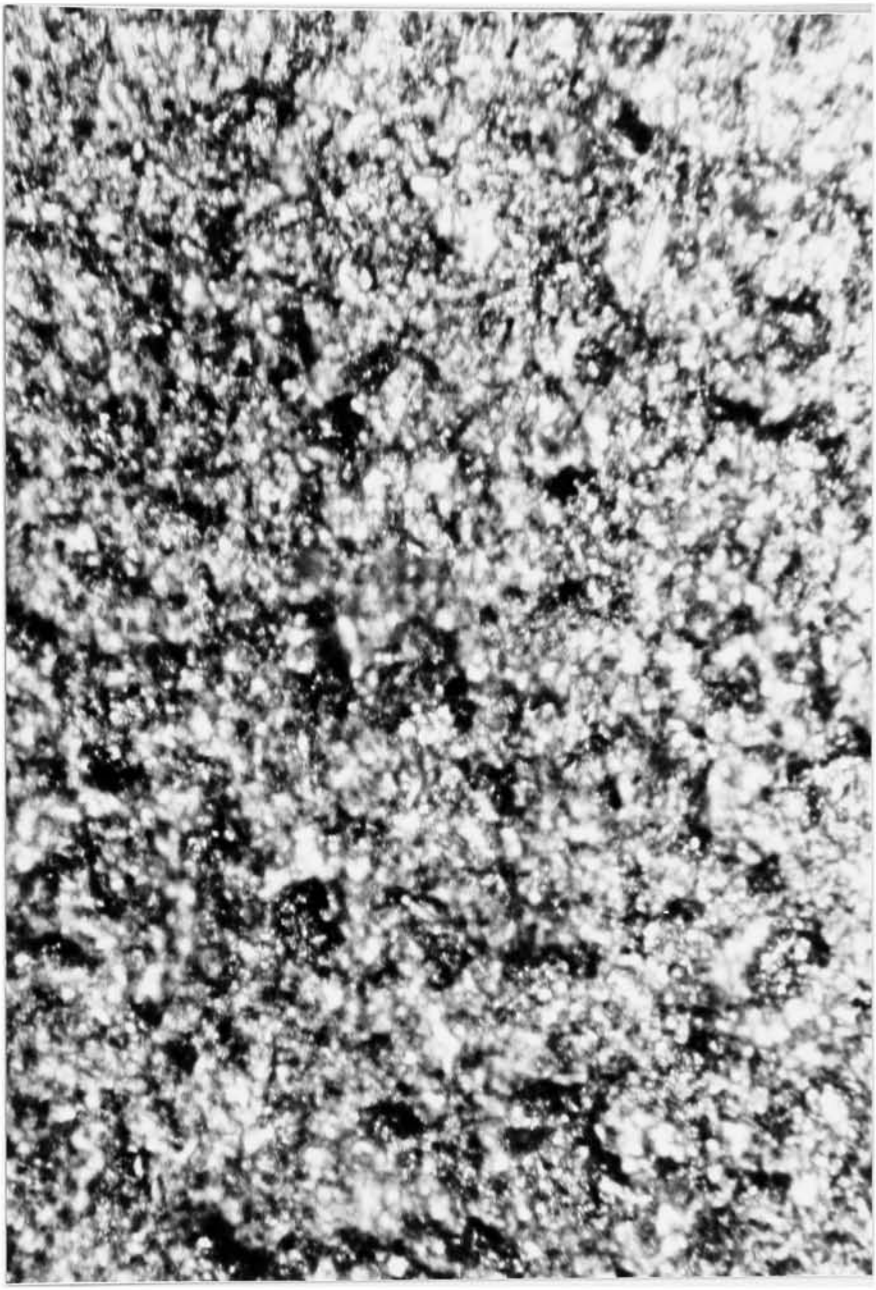


Figure 14. Photomicrograph of the Sandblast Grained Aluminum Plate (ST Plate) at 400X.

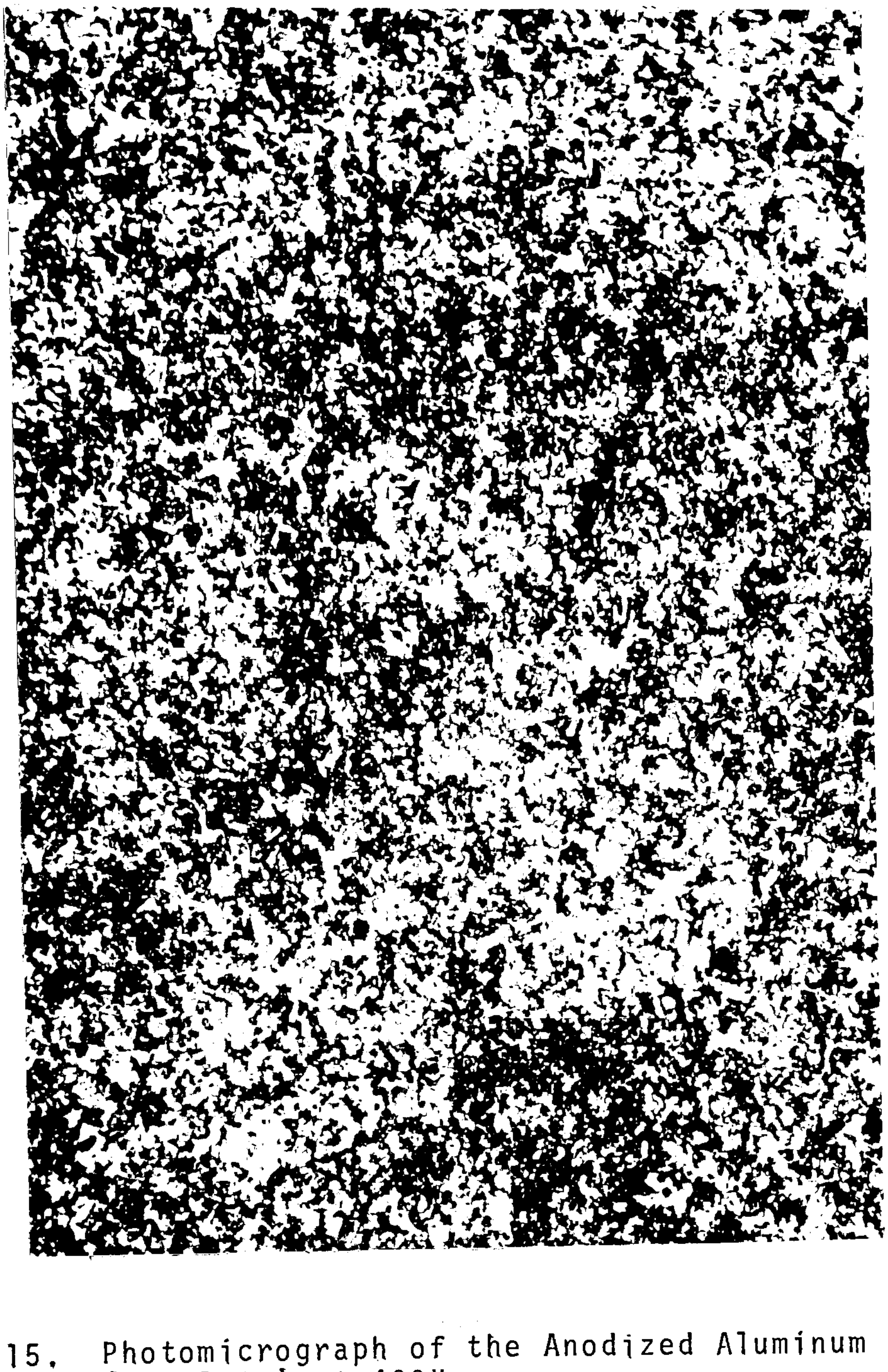


Figure 15. Photomicrograph of the Anodized Aluminum Plate (Azoplate) at 400X.

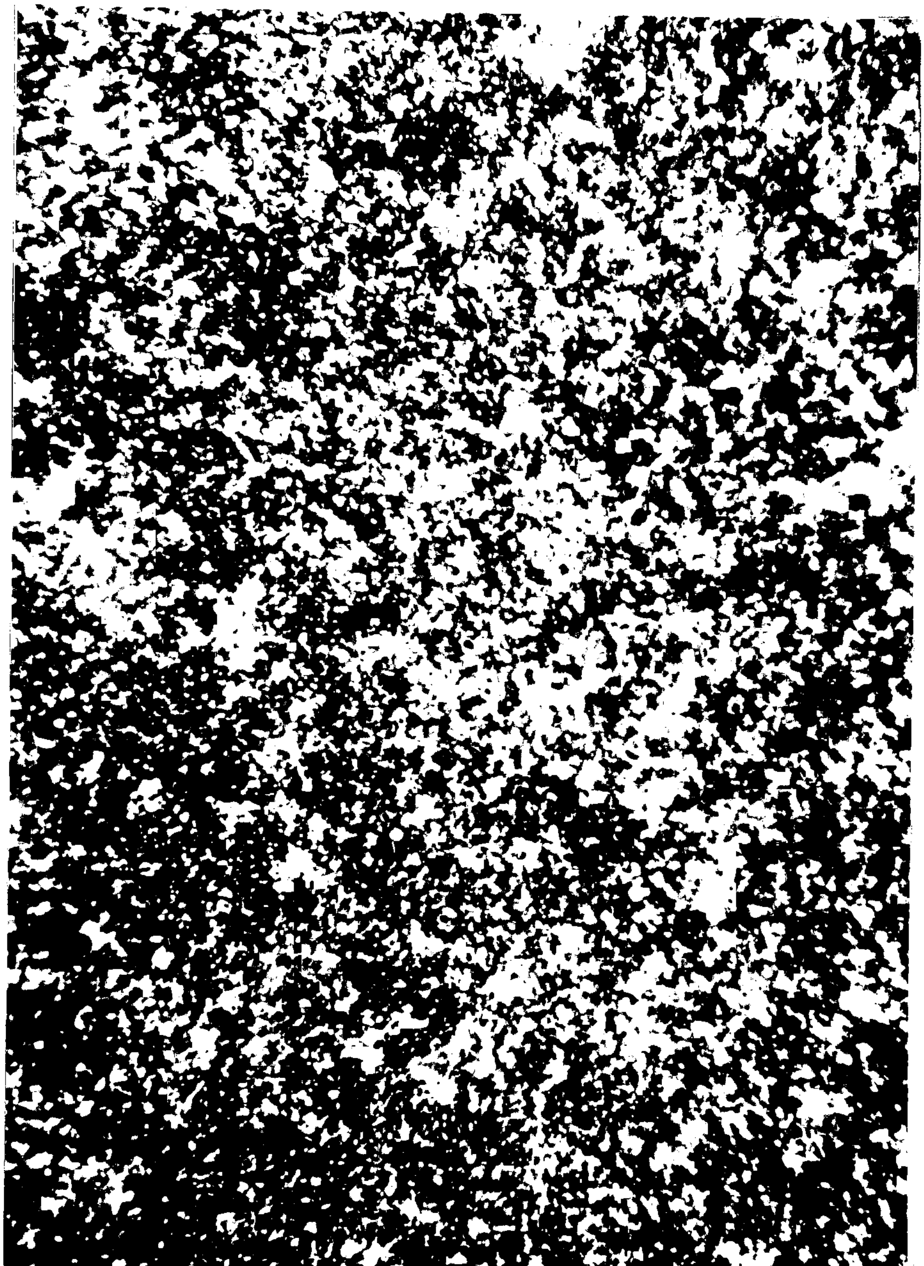


Figure 16. Photomicrograph of the Anodized Aluminum Plate (John Stark S-31) at 400X.

Coarseness Measurement by the Sheffield Smoothchek

The relative coarseness of the grained plates are shown in Table 1. They were analyzed by an analysis of variance and the multiple range test (see Appendix E). The summary of ANOVA table and the multiple range test are shown in Table 2 and Table 3. The results from the statistical analysis are:

1. The sandblast grained plates have the most coarse surface, compared to the others.
2. The brush grained plates are coarser than the chemically grained and the anodized plates.
3. There is no significant difference between the brush grained plates from two manufacturers.
4. The coarseness of the anodized plates and the chemically grained plates are not distinguishable.

The data indicate the rate of air leakage between the smooth metal head of the Sheffield Smoothchek and the surfaces of each sample. They indicate the degree of coarseness of grain. These measurements present the combination of effects of distribution of the grains and depths of the grains. They do not tell which plates have deeper grains nor which have greater distance between grains.

70 Degree Gloss Measurement

The glossiness of the grained plates was measured by the Vanceometer. The data are shown in Table 4.

TABLE 1. COARSENESS OF THE GRAIN MEASURED BY THE SHEFFIELD SMOOTHCHEK (First Set)

Anodized Aluminum	Chemical Grain	Brush Grain (Azoplate)	Brush Grain (Litho Chem.)	Sandblast Grain
4.0	6.5	7.5	6.5	18.0
5.0	7.0	7.5	7.0	20.0
4.0	7.0	8.0	9.0	19.0
4.5	6.5	7.5	7.5	19.5
5.0	6.0	7.5	7.0	21.0
4.0	5.5	8.0	8.0	20.0
4.0	4.5	7.5	8.0	19.0
5.0	4.5	7.0	10.0	19.0
5.0	6.0	7.0	8.0	20.0
4.0	5.0	7.5	8.0	18.0
4.5	5.0	7.5	10.0	20.0
6.5	6.0	8.0	8.0	20.0
$\bar{X}$ 4.62	5.79	7.54	8.08	19.42

TABLE 1. (continued) (Second Set)

	Anodized Aluminum	Chemical Grain	Brush Grain (Azoplate)	Brush Grain (Litho Chem.)	Sandblast Grain
	5.0	4.5	7.0	7.0	23.0
	5.0	6.0	7.0	7.5	21.0
	4.5	6.0	7.5	7.5	23.0
	4.0	5.0	7.0	7.0	18.0
	5.0	4.5	7.5	7.0	21.0
	7.0	5.0	8.0	8.0	22.0
	4.5	5.0	7.5	7.5	23.0
	4.0	4.5	7.0	7.5	22.0
	5.0	4.5	7.0	8.0	20.5
	4.5	4.5	7.0	7.0	19.0
	6.5	5.0	7.5	7.0	21.0
	5.5	4.5	8.0	7.5	18.0
$\overline{X}$	5.04	4.92	7.33	7.38	20.96
$\overline{\overline{X}}$	4.830	5.355	7.435	7.730	20.190

($\overline{\overline{X}}$ is the average of $\overline{X}$ from the first set and the second set.)

TABLE 2. SUMMARY ANOVA FOR GRAIN COARSENESS (Data From Table 1)

Source	Sum of Square	df	Mean Square	Calculated F Ratio	Table F Ratio
Type of Grain	319.7897	4	79.94742	208.2506	5.1922*
Error	1.9195	5	0.38390		
Total	321.7092	9			

*Table F Ratio at the 0.05 level of significance.[1]

$$\text{Calculated F Ratio} = \frac{\text{Variance of Mean}}{\text{Variance of Error}}$$

$$= \frac{79.94742}{0.38390}$$

$$= 208.2506$$

The Calculated F Ratio is more than the Table F Ratio: it indicates that there is a significant difference among the means of grain coarseness.

df = degree of freedom

TABLE 3. COMPARISONS OF INDIVIDUAL MEANS OF GRAIN COARSENESSES
(See Appendix E for method of calculations)

No. of means being compared (g)	Difference of means		SSR	Result of comparison
2	$\overline{X}_c - \overline{X}_a = 0.025$	less than	1.5947	not significant
2	$\overline{X}_{ba} - \overline{X}_c = 2.580$	more than	"	significant
2	$\overline{X}_{bc} - \overline{X}_{ba} = 0.295$	less than	"	not significant
2	$\overline{X}_s - \overline{X}_{bc} = 13.460$	more than	"	significant
3	$\overline{X}_{ba} - \overline{X}_a = 2.605$	more than	1.6385	significant
3	$\overline{X}_{bc} - \overline{X}_c = 2.875$	more than	"	significant
3	$\overline{X}_s - \overline{X}_{ba} = 12.755$	more than	"	significant
4	$\overline{X}_{bc} - \overline{X}_a = 2.900$	more than	1.6604	significant
4	$\overline{X}_s - \overline{X}_c = 15.335$	more than	"	significant
5	$\overline{X}_s - \overline{X}_a = 15.360$	more than	"	significant

$\overline{X}_a$ - Mean of coarseness of the anodized plate

$\overline{X}_{ba}$ - Mean of coarseness of the brush grained plate (Azoplate)

$\overline{X}_{bc}$ - Mean of coarseness of the brush grained plate (Litho Chemical)

$\overline{X}_c$ - Mean of coarseness of the chemically grained plate

$\overline{X}_s$ - Mean of coarseness of the sandblast grained plate

TABLE 4. 70 DEGREE GLOSS MEASUREMENTS

Anodized Grain A		Anodized Grain B		Brush Grain A		Brush Grain B		Chemical Grain		Sandblast Grain	
1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
9.5	10.0	29.0	31.0	27.0	28.0	24.5	25.0	4.0	4.0	12.5	12.5
9.5	10.0	30.0	31.0	27.0	28.0	29.0	36.0	4.0	4.0	12.0	12.0
9.0	9.5	29.0	30.0	27.0	28.0	29.0	40.0	4.0	4.0	12.0	12.0
9.5	9.5	29.0	30.0	26.0	30.0	30.0	34.0	4.0	4.0	12.0	12.0

Anodized Grain A - John Stark Plate S-31, Richardson Graphic Company

Anodized Grain B - Azoplate Company

Brush Grain A - Azoplate Company

Brush Grain B - Wipe-O Plate, Litho Chemical and Supply Company

Chemical Grain - GRNIT 218, Western Litho Plate and Supply Company

Sandblast Grain - ST Plate, Summer Williams, Inc.

The samples were turned 90 degrees before the second measurements were taken. The different readings of the first and the second indicate the presence of directionality of the grains. The brush grained plates and the anodized plates have directionality of grains. This result agrees with microscopic examinations. The brush grain B seems to have less grain uniformity because its data vary more than the others.

The gloss of the brush grains from two manufacturers are slightly different but those of the anodized plates are so different that they can be distinguished visually. The reason for this difference might be that the plates were treated differently before anodizing, such as one of them (one with higher gloss) might be brightened before anodizing, for the desired appearance.

From microscopic examination, it is obvious that the sandblast grained plates have deeper grain than the anodized plate A; but the gloss measurements of the first type is higher than the latter type. This indicates that the gloss measurement does not relate to the depth of grain as reported by Zelley.[2]

The chemically grained plates have very low gloss, i.e., four per cent. This agrees with that reported by George et al. The characteristic of this type of grain is the absence of specular gloss.[3] From these results, it is suggested that microscopic examination should be used to accompany gloss measurements. Otherwise, the data may be misinterpreted.

Coating Thickness

The data for coating thickness are shown in Table 5. They were analyzed statistically by single-factor analysis of variance with six replicates (six samples from each grain). The summary of ANOVA table and the multiple range test are shown in Table 6 and Table 7. The conclusions of the analysis are:

1. The brush grained plates have thinner coatings than do the others.
2. The coating thicknesses of the anodized plates, the chemically grained plates, and the sandblast grained plates are not distinguishable.

In this experiment, the chemically grained plates provide the most uniform coating layers. It was difficult to get a uniform coating on the anodized plates by the whirling method. After they were flushed with water the whirling time for the anodized plates had to be less than 30 seconds, otherwise the sensitizing solution was unable to cover the whole area of the plates. It is suspected that the capillary force of the microporous surface of the anodized plates causes the absorption of the solution, thus creating resistance to flow.

TABLE 5. COATING THICKNESS OF THE GRAINED PLATES
(Milligrams per square inch)

Anodized Grain	Chemical Grain	Brush Grain	Sandblast Grain
0.4972	0.4667	0.3556	0.4639
0.4611	0.4722	0.4222	0.4583
0.4583	0.4611	0.3667	0.4417
0.4111	0.4639	0.4250	0.4583
0.4667	0.4639	0.4222	0.4444
0.4250	0.4611	0.3722	0.4556

Printing Sharpness

Printing sharpness was presented in terms of per cent of tint-solid ratio.[4] The densities of the tint patches were divided by the densities of the solid patches opposite them. The printing sharpness of a plate was obtained from an average of 50 values, five from each press sheet. The data are shown in Tables 8 through 11. They were analyzed by a single-factor analysis of variance with two replicates (the sheets were printed from two plates of each type of grain). The summary of the ANOVA is shown in Table 12. The statistical test shows that there is no significant difference among the printing sharpnesses of the test plates.

Resolution Measurement

The results from the press sheets show that all the test plates can print more detail than the RIT Alphanumeric

TABLE 6. SUMMARY ANOVA FOR COATING THICKNESS (Data from Table 5)

Source	Sum of Square	df	Mean of Square	Calculated F Ratio	Table F Ratio	Result
Type of Grain	0.0185297	3	0.0061759	11.7793	3.0984	significant
Error	0.0104879	20	0.0005243			
Total	0.0290157	23				

TABLE 7. MULTIPLE RANGE TEST FOR COATING THICKNESS
(See the calculations for SSR in Appendix E)

No. of means being compared (g)	Difference of means	more/less	SSR	Result of comparison
2	$\overline{X}_a - \overline{X}_b = 0.05925$	more than	0.0275630	significant
2	$\overline{X}_s - \overline{X}_a = 0.00047$	less than	"	not significant
2	$\overline{X}_c - \overline{X}_s = 0.01112$	less than	"	not significant
3	$\overline{X}_s - \overline{X}_b = 0.05972$	more than	0.0289654	significant
3	$\overline{X}_c - \overline{X}_a = 0.01159$	less than	"	not significant
4	$\overline{X}_c - \overline{X}_b = 0.07084$	more than	0.0297120	significant

TABLE 8. PRINTING SHARPNESS OF CHEMICALLY GRAINED PLATES
(Per cent of tint-solid ratio)

Printing Sharpness of the First Plate

First Column	Second Column	Third Column	Fourth Column	Fifth Column	Mean of Sharpness of one sheet
46.66	50.00	50.81	54.40	34.16	51.206
45.52	49.18	52.45	56.91	54.16	51.644
45.60	48.78	52.45	54.83	54.16	51.164
49.18	50.00	52.45	58.33	55.00	52.992
49.61	49.19	53.33	55.56	55.00.	52.448
48.36	48.00	52.03	56.00	56.19	52.116
47.54	49.58	52.50	55.73	55.00	52.700
46.67	47.93	54.09	49.58	53.33	50.320
46.67	47.50	56.81	54.09	52.45	51.504
46.67	46.72	48.78	55.37	53.71	50.250

The mean of printing sharpness of first plate is 51.57

Printing Sharpness of Second Plate

48.46	49.23	49.61	55.81	55.12	51.646
48.44	48.46	49.23	54.62	55.56	51.260
46.88	48.06	46.88	52.71	57.38	50.382
47.66	49.22	51.20	55.56	55.12	51.752
50.78	47.69	49.21	56.45	57.38	52.302
44.19	46.88	48.46	53.85	55.20	49.716
45.16	45.67	47.69	54.26	53.60	49.276
46.77	47.24	50.39	53.91	55.28	50.718
46.03	47.24	48.06	55.47	53.91	50.142
46.03	46.51	50.00	55.81	54.76	50.622

The mean of printing sharpness of second plate is 50.78

TABLE 9. PRINTING SHARPNESS OF ANODIZED PLATES
(Per cent of tint-solid ratio)

Printing Sharpness of the First Plate

First Column	Second Column	Third Column	Fourth Column	Fifth Column	Mean of Sharpness of one sheet
46.40	47.61	50.00	53.84	54.76	50.522
46.92	48.41	49.60	52.71	54.76	50.780
46.87	47.61	49.60	52.30	51.87	49.650
45.38	48.03	49.60	54.33	52.30	49.928
46.82	47.20	49.20	51.53	53.54	49.658
44.96	45.38	46.50	50.00	52.30	47.828
45.31	46.51	48.81	54.61	53.48	49.774
45.38	46.87	47.69	53.84	52.71	49.298
47.69	47.32	46.92	54.68	53.48	50.018
46.15	46.92	48.43	54.61	56.55	50.532

The mean of printing sharpness of first plate is 49.77

Printing Sharpness of the Second Plate

50.00	53.33	51.20	56.25	54.69	53.094
49.18	52.42	50.78	57.03	56.92	53.266
50.00	52.80	50.78	57.26	57.94	53.666
50.83	54.17	52.89	58.73	57.94	54.912
55.00	50.78	57.26	57.14	55.04	55.045
49.59	55.00	51.56	57.94	57.94	54.406
50.00	56.03	51.20	59.17	58.06	54.892
51.26	55.00	51.20	57.94	56.25	54.330
50.38	53.33	52.89	56.80	56.35	54.040
49.59	33.68	52.45	56.45	58.60	50.046

The mean of printing sharpness of second plate is 53.77

TABLE 10. PRINTING SHARPNESS OF BRUSH GRAINED PLATES
(Per cent of tint-solid ratio)

Printing Sharpness of the First Plate

First Column	Second Column	Third Column	Fourth Column	Fifth Column	Mean of Sharpness of one sheet
48.76	47.58	50.38	54.19	53.90	50.962
48.00	49.60	51.56	53.07	53.96	50.585
46.28	46.03	50.39	53.07	52.75	49.704
47.15	48.38	52.00	53.84	53.22	50.918
45.23	47.61	50.00	53.07	53.12	49.806
45.60	48.00	52.80	54.26	54.26	50.984
46.40	48.00	52.80	54.26	53.90	50.932
48.36	50.40	52.00	54.68	53.07	51.700
47.54	48.00	51.61	53.54	52.80	50.698

The mean of printing sharpness of first plate is 50.70

Printing Sharpness of the Second Plate

45.74	50.81	51.24	47.20	50.39	49.076
44.96	49.21	45.97	49.18	50.00	47.864
43.08	49.59	45.83	46.40	51.20	47.220
44.62	50.00	46.72	48.00	50.00	47.868
46.88	52.07	47.50	47.62	51.16	48.462
43.41	48.00	45.90	47.62	48.24	46.634
48.31	49.21	46.72	46.88	51.54	48.532
45.74	51.20	47.15	48.82	50.38	48.658
48.39	52.03	49.17	49.19	51.56	50.068
48.00	52.03	46.72	50.00	48.51	49.052

The mean of printing sharpness of second plate is 48.34

TABLE 11. PRINTING SHARPNESS OF SANDBLAST GRAINED PLATES
(Per cent of tint-solid ratio)

Printing Sharpness of the First Plate

First Column	Second Column	Third Column	Fourth Column	Fifth Column	Mean of Sharpness of one sheet
52.00	50.00	52.89	56.19	57.37	53.690
52.84	53.96	57.25	52.89	58.06	55.000
52.00	51.16	50.79	56.09	58.06	53.620
51.20	51.58	51.61	57.37	56.00	53.552
51.58	53.71	52.41	57.50	59.50	54.834
51.85	52.38	51.56	58.33	58.06	54.392
51.16	52.71	53.22	57.60	59.67	54.872
54.03	55.64	55.00	60.00	57.37	56.418
51.61	54.76	55.00	58.53	58.54	55.030
53.22	54.33	53.71	57.72	57.03	55.570

The mean of printing sharpness of first plate is 54.70

Printing Sharpness of the Second Plate

44.44	48.39	47.46	53.72	50.82	48.966
46.77	50.39	50.83	51.67	48.78	49.688
44.53	52.42	48.33	51.22	52.46	49.792
45.90	50.40	49.18	52.38	48.06	49.189
45.16	49.21	46.77	50.79	48.44	48.074
44.09	51.61	47.06	50.82	50.83	48.882
45.92	51.64	47.11	52.89	51.67	49.842
45.60	56.81	45.31	51.22	50.00	48.788
44.80	50.00	48.30	52.30	50.00	49.026
48.46	54.26	51.20	56.69	53.90	50.902

The mean of printing sharpness of second plate is 49.51

TABLE 12. VARIANCE ANALYSIS FOR PRINTING SHARPNESS

Level Type of Plate	Replicate Printing Sharpness	
	First Plate	Second Plate
Sandblast grained plate	54.70	49.51
Brush grained plate	50.70	49.34
Chemically grained plate	51.57	50.78
Anodized plate	49.77	53.77

Summary ANOVA for Printing Sharpness

Source	Sum of Square	df	Mean Square	Calculated F Ratio	Table F Ratio	Result
Type of grain	7.908	3	2.6360	0.42928	6.5914	not significant
Error	24.562	4	6.1405			
Total	32.470	7				

Resolution Test Target. Therefore, the resolution data were obtained from the printed GATF Star Targets. The widths of the solid center of the target are shown in Table 13 and Table 14. The averages of the widths, printed from each plate, were substituted in the formula given by GATF.[5]

$$\text{Line per inch} = \frac{11.47}{\text{Width of the solid center}}$$

The calculated resolutions were analyzed by a two-factor analysis of variance with two replicates (Table 15 and Table 16). The two factors are type of grain and magnification. The replicates are the resolution measured from press sheets printed from two sets of plates.

The analysis indicates that there is a significant difference among the resolution means of the four types of grains. The results from the multiple range test show that the anodized plates and the sandblast grained plates have poorer resolution than the chemically grained plates (Table 17).

Theoretically, the anodized plate should produce the highest resolution as it is the finest grain (microscopic examination). One can speculate that this plate is the thickest plate, 0.012 inches, so it is difficult to stretch it on the small press which is not designed for such thick plates. It is suspected that the squeeze pressure between the plate and blanket is more than the other plates which were packed with packing sheets. It was found that after

TABLE 13. THE WIDTHS OF CENTER SOLID OF PRINTED GATF STAR TARGET MEASURED WITH 8X GLASS

With Press Direction(cm.)		Across Press Direction(cm.)	
Plate I	Plate II	Plate I	Plate II
Brush Grained Plate			
0.06	0.04	0.06	0.04
0.04	0.04	0.05	0.05
0.05	0.06	0.04	0.05
0.05	0.06	0.05	0.05
0.04	0.05	0.05	0.05
0.04	0.06	0.05	0.05
0.05	0.05	0.06	0.05
0.04	0.05	0.04	0.05
0.06	0.05	0.04	0.06
0.05	0.05	0.05	0.05
Anodized Plate			
0.06	0.06	0.07	0.06
0.05	0.06	0.06	0.05
0.06	0.06	0.06	0.06
0.05	0.06	0.06	0.05
0.06	0.06	0.06	0.05
0.05	0.06	0.06	0.06
0.06	0.05	0.05	0.06
0.06	0.05	0.05	0.05
0.06	0.05	0.07	0.06
0.06	0.06	0.07	0.06

TABLE 13. (continued)

Chemical Grained Plate

With Press Direction(cm.)		Across Press Direction(cm.)	
Plate I	Plate II	Plate I	Plate II
0.03	0.05	0.04	0.04
0.04	0.05	0.04	0.05
0.04	0.05	0.04	0.04
0.04	0.05	0.04	0.04
0.04	0.05	0.04	0.04
0.03	0.05	0.04	0.04
0.04	0.05	0.05	0.05
0.03	0.05	0.04	0.05
0.04	0.05	0.04	0.05
0.04	0.06	0.03	0.05

Sandblast Grained Plate

0.06	0.06	0.05	0.05
0.05	0.05	0.06	0.05
0.06	0.06	0.05	0.06
0.06	0.06	0.07	0.05
0.06	0.06	0.05	0.05
0.06	0.06	0.05	0.05
0.05	0.05	0.05	0.05
0.06	0.07	0.05	0.05
0.06	0.06	0.05	0.06
0.06	0.05	0.05	0.06

TABLE 14. THE WIDTHS OF CENTER SOLID OF PRINTED GATF STAR TARGET MEASURED WITH 40X MICROSCOPE

Brush Grained Plate

With Press Direction(cm.)		Across Press Direction(cm.)	
Plate I	Plate II	Plate I	Plate II
0.05	0.05	0.06	0.05
0.05	0.05	0.06	0.05
0.04	0.05	0.06	0.05
0.05	0.05	0.06	0.04
0.06	0.05	0.06	0.04
0.06	0.04	0.06	0.04
0.06	0.04	0.05	0.04
0.05	0.05	0.05	0.05
0.06	0.04	0.05	0.05
0.05	0.05	0.05	0.05

Anodized Plate

0.06	0.06	0.06	0.07
0.06	0.06	0.06	0.06
0.06	0.06	0.05	0.06
0.05	0.06	0.05	0.06
0.05	0.06	0.07	0.06
0.07	0.06	0.06	0.06
0.06	0.05	0.06	0.06
0.06	0.06	0.07	0.05
0.06	0.05	0.06	0.06
0.06	0.06	0.06	0.06

TABLE 14. (continued)

Chemical Grained Plate

With Press Direction(cm.)		Across Press Direction(cm.)	
Plate I	Plate II	Plate I	Plate II
0.06	0.04	0.06	0.05
0.06	0.05	0.05	0.05
0.05	0.04	0.05	0.05
0.05	0.04	0.05	0.04
0.05	0.05	0.06	0.05
0.06	0.05	0.06	0.04
0.05	0.04	0.06	0.04
0.06	0.04	0.06	0.04
0.06	0.05	0.06	0.04
0.07	0.05	0.06	0.05

Sandblast Grained Plate

0.05	0.05	0.05	0.05
0.06	0.05	0.06	0.05
0.05	0.05	0.05	0.06
0.06	0.06	0.06	0.06
0.06	0.06	0.05	0.05
0.05	0.04	0.05	0.05
0.06	0.05	0.05	0.06
0.06	0.06	0.05	0.05
0.06	0.05	0.05	0.05
0.06	0.05	0.05	0.06

TABLE 15. RESOLUTION OF THE GRAINED PLATES (Lines per inch)

Magnification	Grain Type			
	Anodized Grain	Brush Grain	Chemical Grain	Sandblast Grain
8X	493	600	606	524
	506	576	756	524
40X	481	626	511	534
	493	534	647	549

TABLE 16. SUMMARY ANOVA FOR RESOLUTION OF THE GRAINED PLATES

Source	Sum of Square	df	Mean of Square	Calculated F Ratio	Table F Ratio	Result
Type of grain	42,696.5	3	14,232.17	4.5030	4.0662	significant
Magnification	2,756.2	1	2,756.20	0.8720		not significant
Interaction	8,174.3	3	2,724.77	0.8620		not significant
Error	25,287.0	8	3,160.88			
Total	78,914.0	15				

TABLE 17. MULTIPLE RANGE TEST FOR THE RESOLUTION MEASUREMENTS (See the calculation for SSR in Appendix E)

No. of means being compared (g)	Difference of means		SSR	Result of comparison
2	$\bar{X}_s - \bar{X}_a = 39.50$	less than	91.6415	not significant
2	$\bar{X}_b - \bar{X}_s = 51.25$	less than	"	not significant
2	$\bar{X}_c - \bar{X}_b = 46.00$	less than	"	not significant
3	$\bar{X}_b - \bar{X}_a = 90.75$	less than	95.6415	not significant
3	$\bar{X}_c - \bar{X}_s = 97.25$	more than	"	significant
4	$\bar{X}_c - \bar{X}_a = 136.75$	more than	97.5448	significant

$\bar{X}_a$ - Mean of resolution of the anodized plate

$\bar{X}_b$ - Mean of resolution of the brush grained plate

$\bar{X}_c$ - Mean of resolution of the chemically grained plate

$\bar{X}_s$ - Mean of resolution of the sandblast grained plate

SSR - Significant studentized range

a few hundred impressions the plate clamps would loosen and printing slur appeared on the press sheets (observed from the Slur Bar and solid center of the Star Target). At an ink density about 1.10 the anodized plates could print detail up to 790 lines per inch.

The resolution of the chemical grained plates was quite different; 150 lines per inch at 8X and 136 lines per inch at 40X. It was found that ink densities of the solid patches printed from the first set were slightly lower than those printed from the second. These densities are still in the control range, 1.25 $\pm$ 0.05 (dry measurement), but those of the first group fell on the lower side, 1.20 - 1.25, and those of the second group on the upper side, 1.25 - 1.30, (see Figure 17). The higher the ink level, the more ink spread. The Star Target is very sensitive to the amount of ink spread. This explained why the resolution of the chemically grained plates was so different.

In this experiment, the magnifications, 8X and 40X were chosen to measure the resolution because at 8X it is easier to determine the definition of the solid center of a printed Star Target, and at 40X it is easier to measure them with the micrometric scale. By means of two-factor variance analysis, the effects of magnification were taken into account. The result indicates that there is no difference when either 8X or 40X is used.

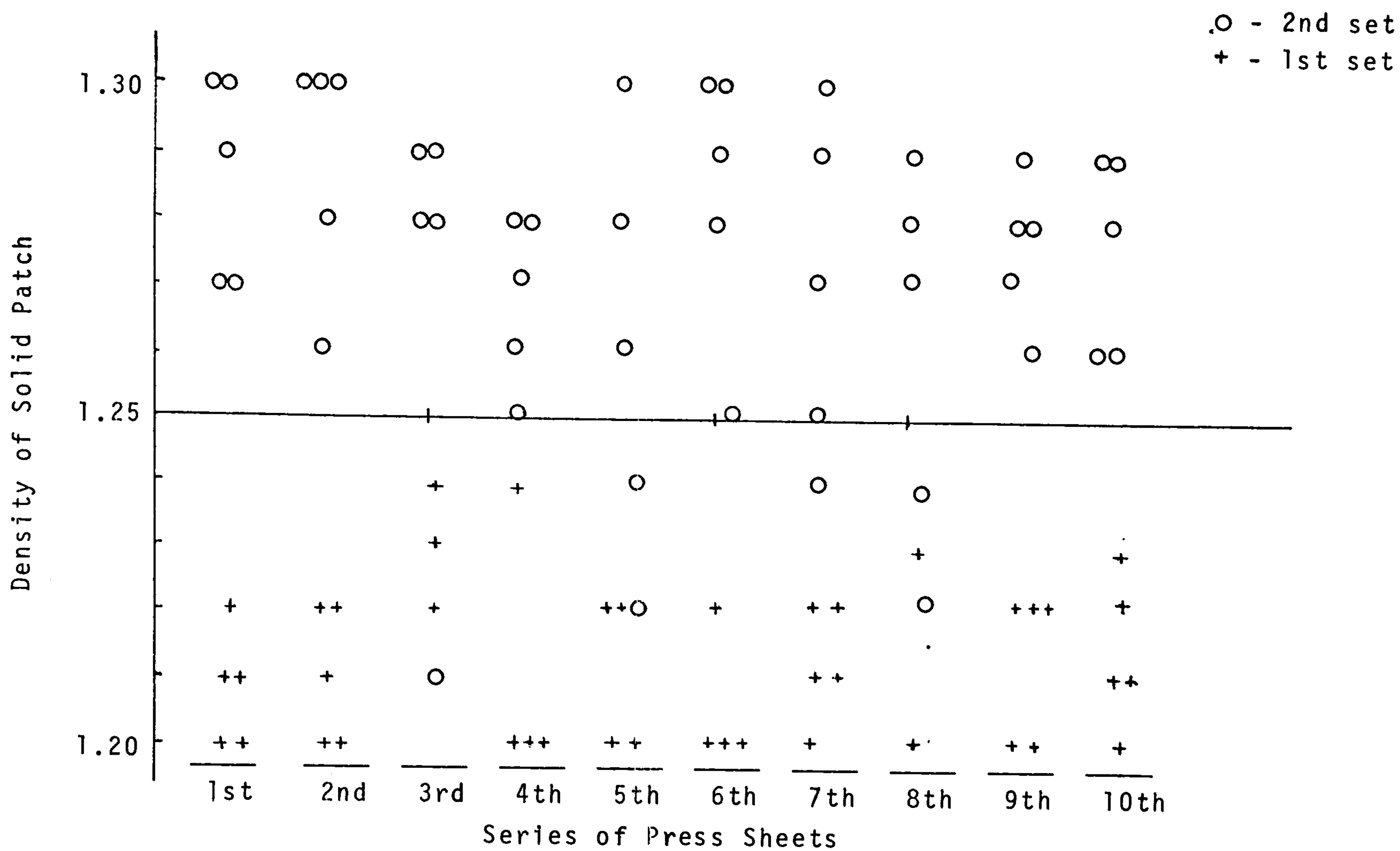


Figure 17. Densities of the Solid Patches Printed from Two Chemical Grained Plates. (10 press sheets from each plate)

Tone Reproduction

The plates tone reproductions are presented in terms of printing characteristic curves (the curves were obtained by plotting density of printed sheet against the dot area of the halftone negative from which it was made.[6] See Appendix F.). They are shown in Figure 18 and Figure 19. They appear in the same shape and are almost superimposed on each other. This type of curve is one of the important tools for controlling reproduction quality.[7] In this experiment, the results show that the test plates produce comparable reproductions.

Wettability of Grained Aluminum Plates

The contact angles of uncoated plates are shown in Table 18. Those measured during the press run are shown in Figure 20 and Figure 21. Two sets of test plates were run on the press, each under different conditions. One set was run at a lower ink level at higher press speed and with the measurements taken inside the printed area. The other set had measurements taken outside the printing areas of the plates.

The reason for the changes was to see the variation of the contact angles at different positions on the plates. During the experiment, it was observed that the contact angles inside the printed area (see Figure 4) change faster than those at the edges of the plates.

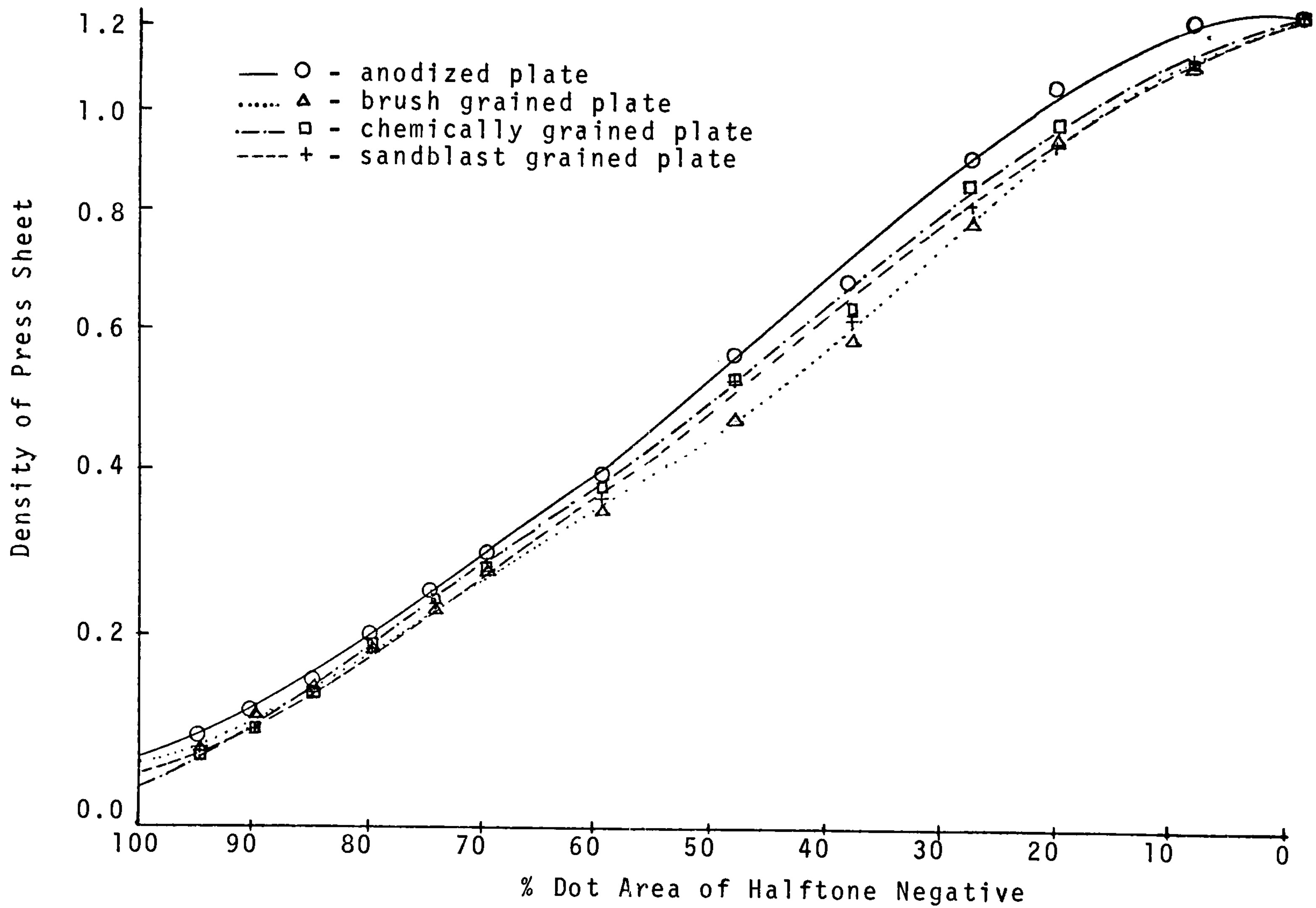


Figure 18. Printing Characteristic Curves of the Grained Plates (Set 1).

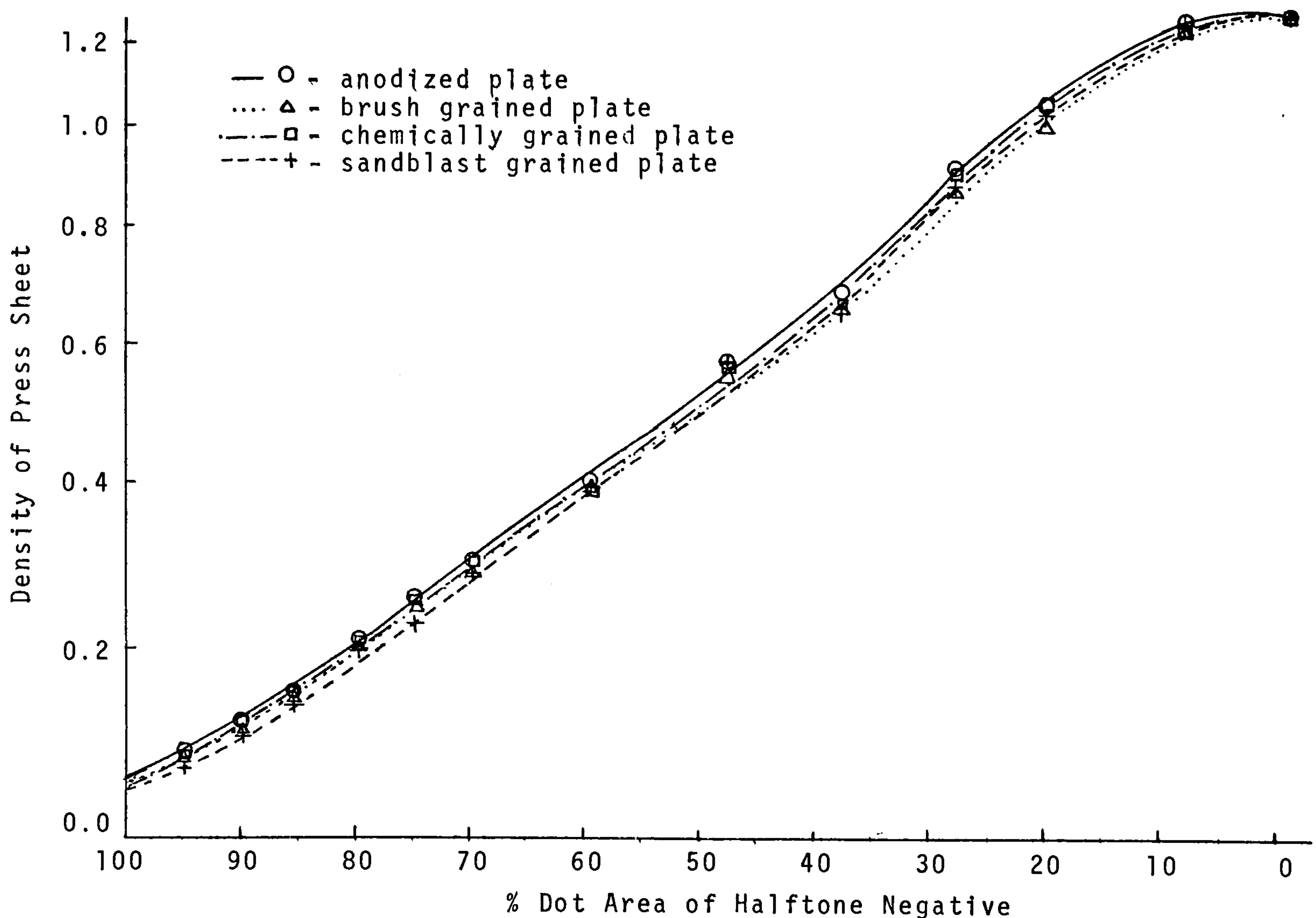


Figure 19. Printing Characteristic Curves of the Grained Plates (2nd set).

In Figure 20 and Figure 21 the contact angles are plotted against the number of impressions. Both show that the contact angles of the chemically grained and the sandblast grained plates changed faster than those of the anodized and the brush grained plates (the brush grained plate in the first set could not run further because its serated holes were torn). The anodized plate in the first set was run to 8,000 impressions and the contact angles were still low (10 and 15 degrees).

The contact angles of the plates in the second set change faster than those of the first set. They indicate that position of the printing plate affects the change of contact angle. To confirm this conclusion, another sandblast grained plate was run under the same conditions as the second set, but the contact angle measurements were taken at the edges of the plate. The contact angles of this plate changes more slowly than that of the sandblast grained plate of the second set, (see Figure 21 and Figure 22).

TABLE 18. CONTACT ANGLE OF UNCOATED PLATES

Type of Plate	Contact Angle (degrees)
Chemical Grain	10
Sandblast Grain	10, 15
Brush Grain (Litho Chemical)	10
Anodized Grain (Azoplate)	17, 20

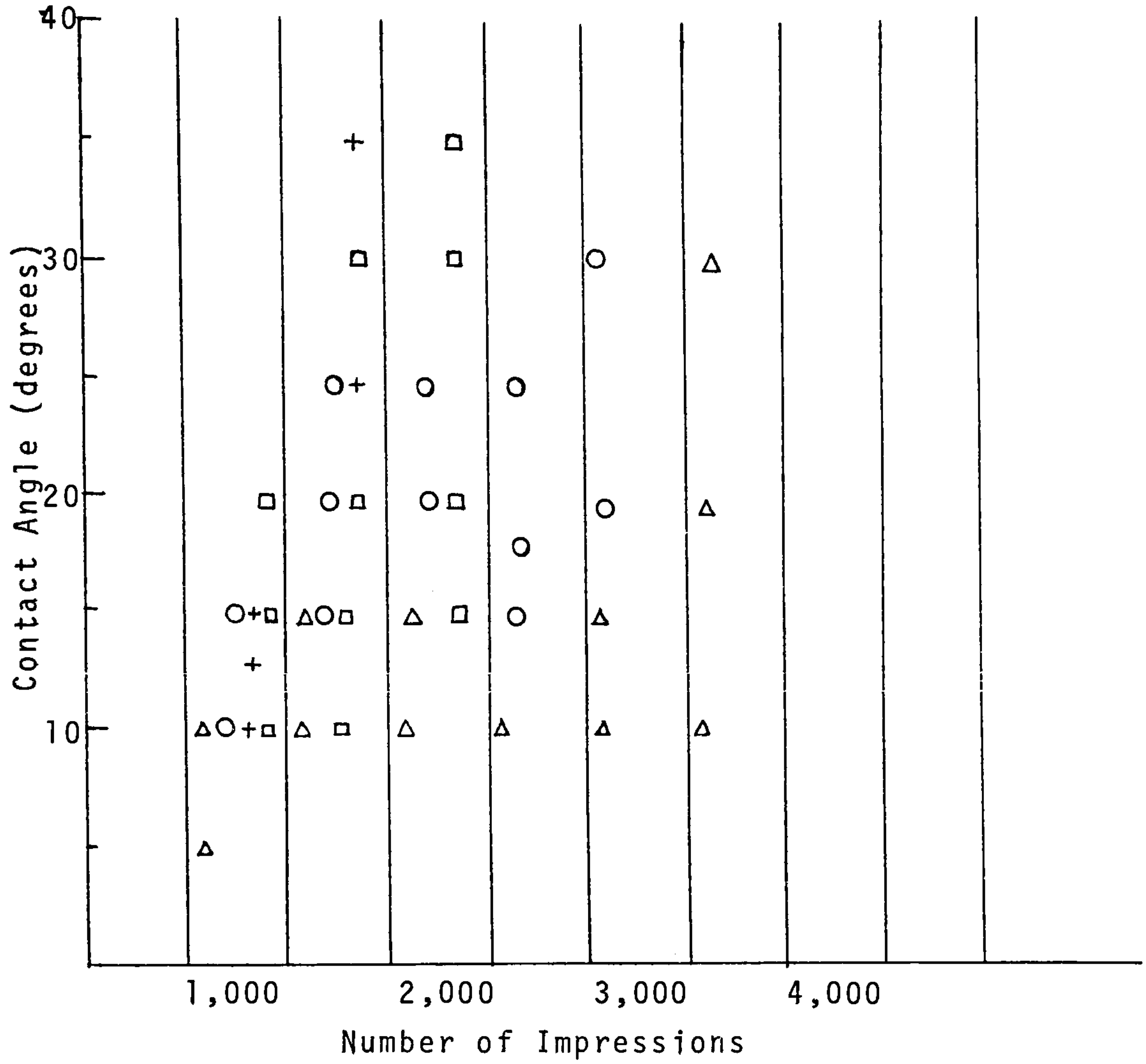


Figure 20. Contact Angles of the Printing Plates During the Pressruns. (Second Set)

O - anodized plate
Δ - brush grained plate
□ - chemically grained plate
+ - sandblast grained plate

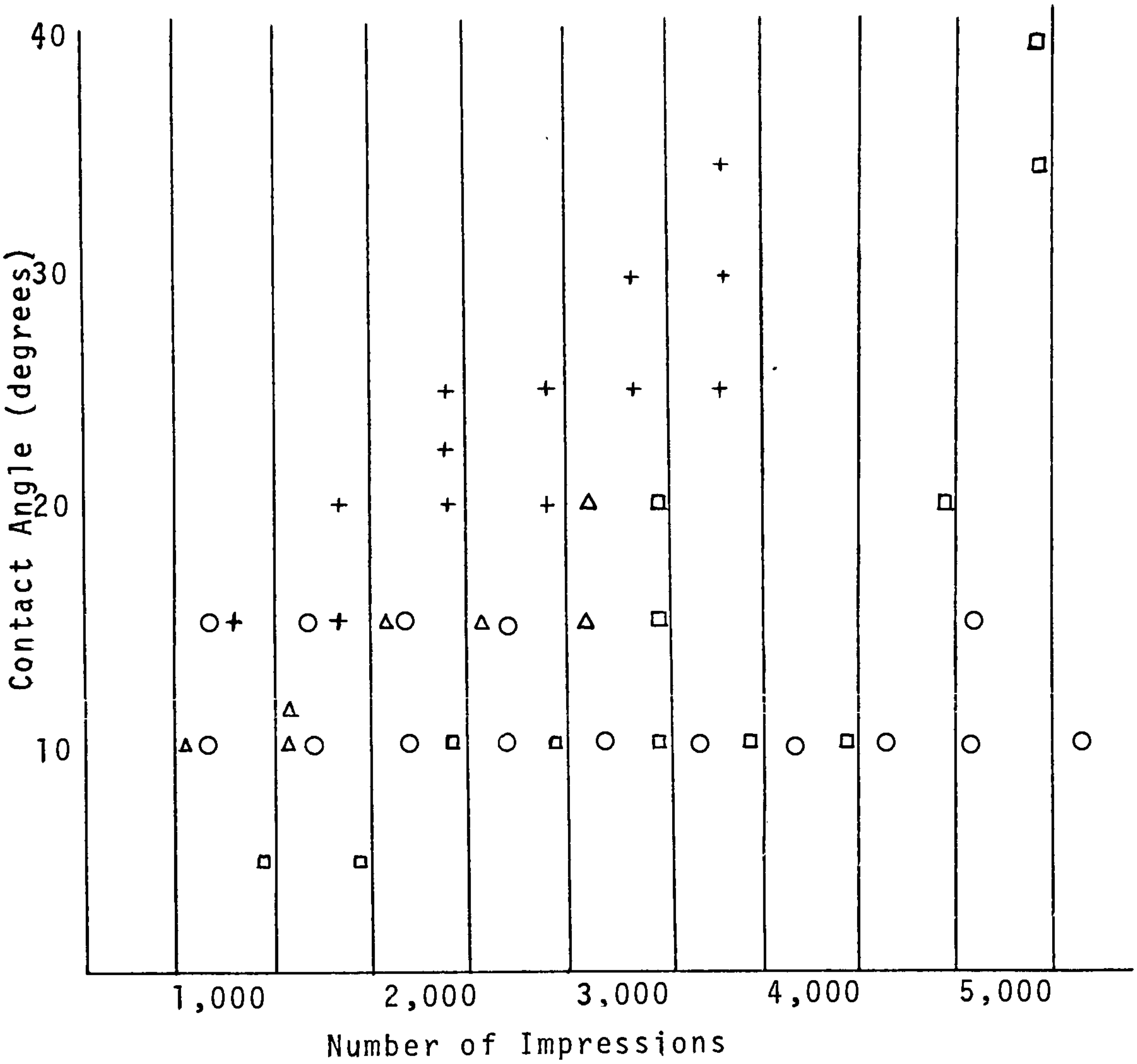


Figure 21. Contact Angles of the Printing Plates During the Pressruns. (First Set).

O - anodized plate
Δ - Brush grained plate
□ - chemically grained plate
\+ - sandblast grained plate

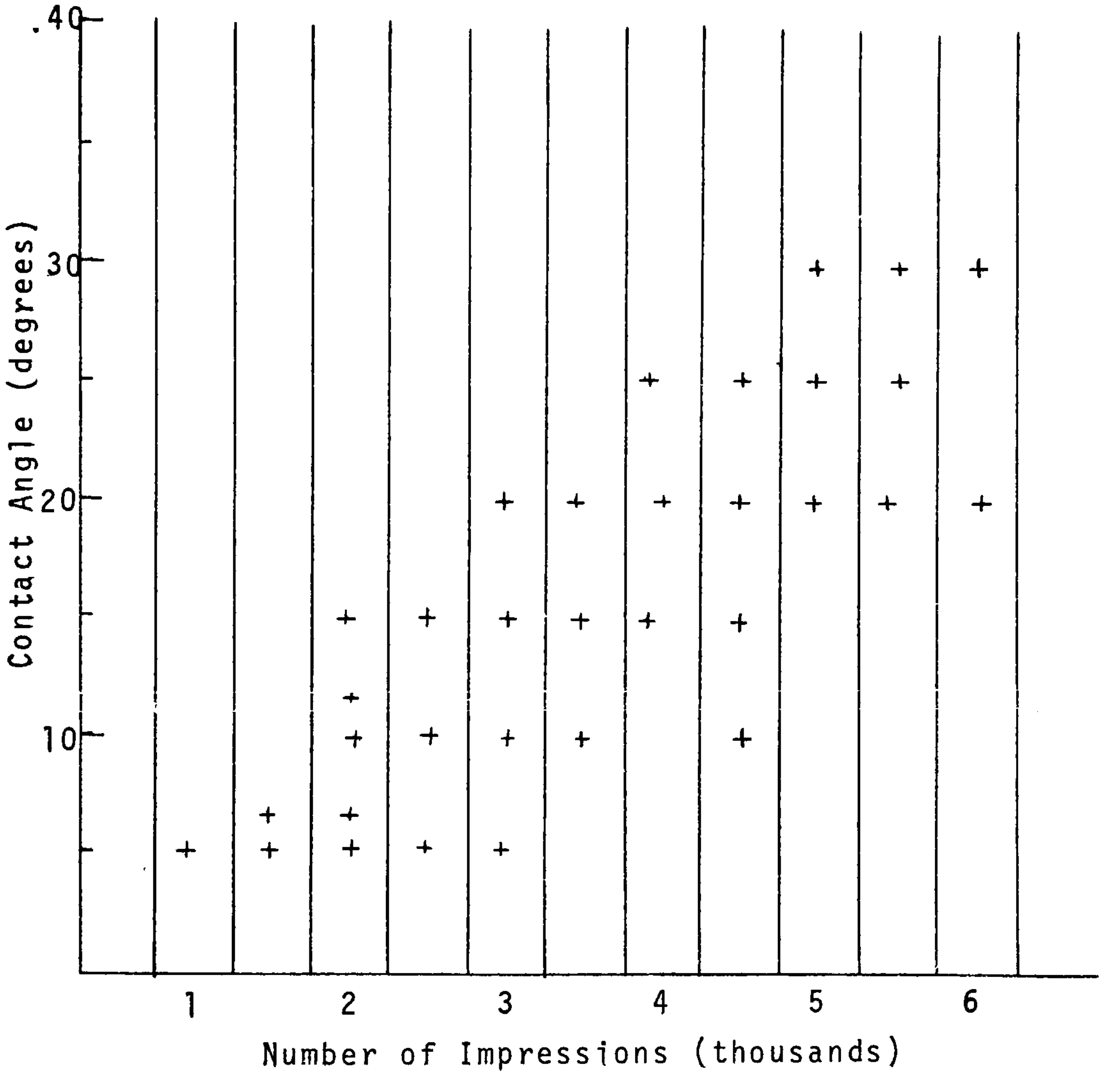


Figure 22. Contact Angle of the Sandblast Grained Plate During the Pressrun.

The contact angles of the test plates increased as the number of impressions increased. It indicated that the wettability of the plates change according to their run-life. There are four possible factors which could cause the plates to become less hydrophilic.

1. Contamination on the plate surfaces due to age, storage condition and manufacturing defect.
2. Ink particles, vehicles and driers which adhere to the plate surface during the press run.
3. Materials from the paper surface which transfer to the plate surface.
4. The abrasion of ink, paper and blanket.

Contamination on the Plate Surfaces due to Age, Storage Conditions and Defect from Manufacturers

This type of contamination on the plate surface could be oxidation or corrosion during storage or manufacturing defects. For aluminum plates, this contamination will cause "ink dot scum".[8] (See Appendix G).

Since the test plates were designed for wipe-on plate systems, they were chemically treated after being grained in order to prevent interaction of metal and diazo resins. It is generally known that these substrates have unlimited shelf life as long as they are uncoated with the light sensitive solution.[9] This is one of their advantages over presensitized plate systems. They are not sensitive to temperature and humidity. For these reasons, this factor is expected to be of minor influence.

· Ink Particles, Vehicles and Driers which Adhere to the Plate Surface

The success of the lithographic process depends on the precise chemical differences between image area and a non-image area. At the present time there is no such ideal situation.

Scumming and Tinting

Scumming is the phenomenon in which non-image areas of a plate become ink receptive and begin to print. The mechanisms of scumming have been studied by several researchers.[10,11] Their findings indicate that most ink vehicles and driers spread on fountain solution surfaces in lithographic printing. This spreading layer is a monomolecular film. It is insoluble and could transfer to an inadequately desensitized aluminum plate to make the area hydrophobic and thus ink receptive.

Another phenomenon is tinting which is the emulsification of ink into the dampening solution on the plate. Both tinting and scumming can take place simultaneously. A plate cleaner and use of more fountain solution are normally used to remedy these conditions.

In this experiment the plates were cleaned by running the press with both ink rollers and a dampening roller down but no press sheets were run through. It is possible that ink was still left on the plate surfaces, but there was not enough to show scum.

The Abrasion of Ink, Paper and Blanket

On the press, the printing plate contacts the ink form rollers, the dampening form roller and the blanket cylinder. The pressure from these rollers and the blanket cylinder abrade the plate surface. After a number of impressions the abrasion might affect both image and non-image areas. The gum film might be partly removed and allow the plate to become less hydrophilic. This factor will cause permanent change of the plate surface, but it seems to occur after a long run This experiment was designed to compare plate performance in short runs and so this factor was not expected to have much influence on the change of the contact angle of the plates.

The change of the contact angle during the press run was expected to be faster than during printing conditions where there was infrequent stoppage of the press. The press was stopped frequently (every 500 impressions) and the plates were dried for 15 minutes before the measurements were taken. This drying time, and the time for measurements (about 20 minutes), could have affected the hydrophilic property of the plates. Under production conditions, the plates would not be allowed to stand that long without being gummed.

Image Adhesion

The experimental condition exaggerated normal press conditions since the blanket was overpacked with a sheet of plastic, thus increasing the squeeze pressure. Under such conditions the sandblast grained plate and the chemically grained plates show an advantage over the brush grained plates and anodized plates. The test plates were run up to 3,000 impressions. They were periodically taken off the press and examined with a microscope at 40 and 100 magnification. After 3,000 impressions the lacquer on the peaks of the grains was already removed. The anodized and brush grained plates had many imperfect dots (first step of the 150 lines per inch Bychrome scale) while those on the chemically grained and the sandblast grained plates were still in good condition. The image of Figure 5 in that step was also observed. The removal of image in this area was different on each type of grain. In sandblast and chemically grained plates they appear as spots, but in the anodized and the brush grained plates they appear in a platelet shape (see Figure 23).

The sandblast grain was run to 10,000 impressions and the dots in the same patch were almost completely removed. But the coating in the valleys of the grains still remained in the plate and were printed on the press sheets.

It is difficult to detect image removal on the press sheets. Since the pressure between the blanket cylinder and the impression cylinder was increased, the printed dots on the press sheets looked perfect, even though the dot shape in the plate were already distorted. When ink and water were off balance, i.e., too much water, some dots disappeared from the press sheets but the images were still on the plate.

Sandblast grained plate
chemical grained plate

Brush grained plate
Anodized plate

Figure 23. Diagrams of Image Removal on the Grained Plates.

FOOTNOTES FOR CHAPTER IV

[1]Albert D. Rickmers and Hollis N. Todd, Statistics: An Introduction (New York: McGraw-Hill Book Co., 1967), p. 559.

[2]W. G. Zelley, "Surface Characteristics of Ball Grained and Brush Grained Aluminum Lithographic Plates," TAGA Proceedings, 1972, p. 266.

[3]D. J. George, C. J. Walton, and W. G. Zelley, "Chemical Pretreating and Finishing," Aluminum vol. 3: Fabrication and Finishing, ed. Kent R. Van Horn, (Metals Park: American Society for Metals, 1967), p. 604.

[4]Warren L. Rhodes, "Study of Objective Methods for Evaluating Sharpness in Lithography," TAGA Proceedings, 1955, pp. 109-122.

[5]George W. Jorgensen, General Memo No. 4: The GATF Star Target for Ink Spread and Resolution Measurements (Pittsburgh: Graphic Arts Technical Foundation, Inc., rev., 1970), pp. 1-4.

[6]John A. C. Yule, "Variation of Tone Reproduction in Halftone Processes," in Advance in Printing Science and Technology vol. 1: Printing Inks and Color, ed. W. H. Banks (New York: Pergamon Press, 1961), p. 48.

[7]Ibid., pp. 48-66.

[8]Paul J. Hartsuch, Chemistry of Lithography (Pittsburgh: Graphic Arts Technical Foundation, Inc., 1961), pp. 307-308.

[9]Gyan P. Maden, "A Detail Report on Wipe-On Litho Plates," Printing Production, April 1961, p. 49.

[10]W. D. Schaeffer, C. Y. Kuo, and A. C. Zettlemoyer, "Monomolecular Film Transfer as Applied to Lithographic Scumming," in Advance in Printing Science and Technology vol. 2: Problems in High Speed Printing, ed. W. H. Banks (New York: Pergamon Press, 1962), pp. 247-265.

[11] W. H. Bank, D. H. Charlesworth, and A. H. Smith, "The Water-Air Boundary in Lithography," in Advances in Printing Science and Technology vol. 6: Recent Developments in Graphic Arts Research, ed. W. H. Banks (New York: Pergamon Press, 1971), pp. 15-38.

CHAPTER V

CONCLUSIONS AND RECOMMENDATION

The experiments were designed to study and compare the surface characteristics, printing quality and plate performance of different types of grained aluminum lithographic plates. The test plates included anodized, brush grained, chemically grained and sandblast grained plates. They were prepared using the same chemicals and procedures.

The press condition was adjusted according to the general standard procedure used with presensitized plates. The plates were run on the same press using the same ink, fountain solution and paper.

Characteristics of Grained Surfaces

Three methods for studying grained aluminum plates, including microscopic examination, coarseness measurement and 70 degree gloss measurement, were used.

The depths and distribution of the grains measured by the Sheffield Smoothchek show that the anodized and the chemically grained plates are the smoothest, and the brush grained plates are smoother than the sandblast grained plates.

It is not possible to measure the depth or distribution of grain by the 70 degree gloss measurement but it can be used to detect the presence or absence of directionality of grain.

These characteristics of the grained plates do not have any relation to their coating thicknesses. The anodized, the chemically grained and the sandblast grained plates have the same coating thickness when they are coated by whirlers. The brush grained plates have thinner coatings than do the others.

Printing Quality

The test plates have such fine grains that their printing quality cannot be distinguished by densitometric measurements or printing sharpness determinations.

Statistical analysis indicates that the chemically grained plates have superior resolution when measured from printed Star Targets.

The tone reproduction curves of the test plates are almost alike.

Plate Performance

The plate performances were determined by the change of contact angle of the plates during the press runs. It was found that the anodized and the brush grained plates have better performance on the press than do the chemically grained and sandblast grained plates.

Image Adhesion

Under exaggerated printing pressure conditions, the tests show that the chemically grained and the sandblast grained plates have better image adhesion than do the anodized and the brush grained plates.

Recommendations for Further Study

In future work, the press may be adjusted to obtain the optimum condition for each grained plate.
A microdensitometer may be used to detect the differences in printing quality.[1] The ink consumption of the grained plates may be investigated. In this experiment it was observed that when the anodized plates were run on the press less ink and dampening were required to obtain the same solid ink density when compared to the other plates used.

FOOTNOTE FOR CHAPTER V

[1]George W. Jorgensen, "Graininess in Lithographic Prints," TAGA Proceedings, 1955, pp. 102-108.

APPENDICES

APPENDIX A

WETTABILITY AND CONTACT ANGLES OF LITHOGRAPHIC PLATES

Wettability is defined as the behavior of a liquid and a solid when the liquid is trying to spread on the solid.[1] It is an important requirement of the metals used in making lithographic printing plates, especially in the multimetal system. A non-image area must be water receptive and an image area must be ink receptive. The method that has been used to study the wettability of printing plates is the measurement of contact angles.

A contact angle is the angle that a tangent to a drop of a liquid makes with a flat surface at the point where the drop touches the solid.[2] The angle may vary from 0 degrees (complete wetting) to 180 degrees (no wetting). There are three interfacial tensions, namely liquid/solid, liquid/air and solid/air, that determine the contact angles (see Figure 24).

When the air is replaced by another liquid, the contact angle is called the interfacial contact angle. This technique was used to study the wettability of various metals for bimetal plates.[3] The plate is immersed in water

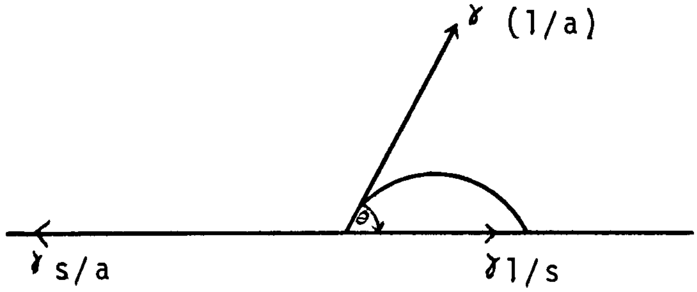


Figure 24. Interfacial Tension, (γ is the symbol for the interfacial tension).

and a drop of oil is placed below the plate by means of a bent pipette. The magnified image of the drop is projected to a screen where the contact angle is measured.

FOOTNOTES FOR APPENDIX A

[1] R. R. Coupe, Science of Printing Technology (Cassell: Cassell & Co. Ltd., 1966), p. 76.

[2] Ibid.

[3] Paul J. Hartsuch, Chemistry of Lithography (Pittsburgh: Graphic Arts Technical Foundation, Inc., 1961), p. 179.

APPENDIX B

PRELIMINARY TEST ON COATING WIPE-ON PLATES

Normally wipe-on plates are preteated chemically by manufacturers. They are ready to be coated without cleaning. The plates may be coated merely by wiping with sponge-like or other lint-free materials. When a large number of plates is required, coating by a roller coater machine is more preferable. In these experiments the plates were coated by whirlers in order to eliminate variation of coating by hand.

The procedure was the same as referred to previously. The time for whirling the plates, after they were flushed with water, was varied to find the proper period, and 30 seconds seemed best. If it was less than this, a pattern of white spots appeared on the coated plates. On the other hand, if it was more than 30 seconds, the coating layer was not uniform. The problem when the plates are coated by this technique is dust. However, in the preliminary test, the coating thickness did not vary as much as expected although the amount of coating solution and drying time were not the same for every plate. The data are shown in Table 18. In this test only brush grained plates were used, since they were the only type available at that time.

TABLE 19. COATING THICKNESS OF BRUSH GRAINED PLATES

Weight before Coating (gms)	Weight after Coating (gms)	Weight of Coating (milligrams/sq. inch)
9.6356	9.6486	0.3638
9.6378	9.6508	0.3611
9.5871	9.6017	0.4056
9.5969	9.96118	0.4138
9.7464	9.7597	0.3694
9.7122	9.7259	0.3806
9.5960	9.6106	0.4056
9.5950	9.6093	0.3972
9.7410	9.7552	0.3944
9.7530	9.7660	0.3611

$\overline{X}$ = 0.38526 mgs/sq. inch

Standard Deviation = 0.0246

APPENDIX C

EXPOSURE TIME OF THE TEST PLATES

All the printing plates were exposed to a carbon arc lamp and were developed to obtain a solid step #6 of the Kodak T-14 Scale. The exposure times of the plates are listed in Table 20. The results of these exposure times were consistent when the experiment was repeated.

TABLE 20. EXPOSURE TIME OF THE TEST PLATES

Type of Grain	Exposure Time (minutes)
Anodized Grain	2-3/4
Chemical Grain	2
Brush Grain	2-1/2
Sandblast Grain	2-1/2

APPENDIX D

ALUMINUM PLATE GRAINING AND ANODIZING

In the past, it was found difficult to print from a smooth surface because water tended to collect in drops instead of spreading evenly. The plate was therefore grained to provide a rough surface which helped to spread the water and also helped the image to adhere to the plate. Many types of grained plates are available for the wipe-on plate process. Some graining procedures used by plate manufacturers are:

Sandblast Graining

> "The plates are carried on a revolving drum which is transversed by a blasting gum through which the sand is forced with air pressure.... The type of grain produced is controlled by drum and transverse speed, air pressure, gun distance and angle and type of abrasive."

Brush Graining

There are two types of brush graining, dry brush graining and wet brush graining. The first was described as follows:

> "A very fine grain can be produced by the abrasion action of revolving brushes. In one method, brushes with steel bristles revolving at a high speed abrade the metal surface giving a coarse grain. A second brush

with finer bristles, rotating in the opposite direction, is used to produce a finer grain and complete the operation."[2]

"Wet brush grain: the plates are fed onto a conveyor belt under nylon brushes and graining is done with a mixture of pumice and water. This process requires several passes through the machine to get evenly grained surfaces without indications of rolling-mill streaks."[3]

Chemical Graining

Chemical graining or chemical etching in this report refers to the technique used to produce surface roughening. Alkaline etches are the most widely used process to produce a matte surface suitable for lithographic printing. The etchant that is useful for this application is trisodium phosphate. Another well-known etchant is sodium hydroxide. This process gives round bottom pit grains.[4] This structure is also called a microporous surface.[5] Chemical graining is also done with an acid solution, but it is not widely used because it is more expensive in both chemicals and equipment.

Anodized Aluminum

Anodizing is an electrolytic oxidation process in which the surface of the metal is converted to a coating having desirable protective, decorative, or other properties.[6] In this process, aluminum is made the anode in a suitable electrolyte, and a metal or carbon is the cathode. An electric current is passed through the cell and the aluminum surface is converted to an aluminum oxide coating. This oxide coating is integral with the aluminum and has excellent adherence. Before anodizing, aluminum plates may be mechanically or chemically grained.[7,8] The process used for making lithographic plates is "conventional" anodizing which produces a coating thickness between 0.0001 and 0.0012 inches.[9] The anodic coating is porous. It has a cellular structure with the cell oriented perpendicular to the metal surface. The characteristics of the cells have an important effect on the coating characteristics. A recent research paper reported that the wear resistance of anodized aluminum plates depends on the size of the cells of the coating.[10] The larger the cells, the more wear resistance. The individual cells of the anodic coating contain a capillary pore in the center. These pores are usually sealed in boiling water. Water reacts with the anodic coating to form alpha alumina hydrate which occupies a greater volume than the alumina from which it was formed. This process is used to increase corrosion and staining resistance. However, it has been found that this sealing method reduces abrasion resistance of the anodic coating.[11]

Anodized aluminum has been considered an ideal plate material for lithographic printing.[12] Its microporous structure, incidentally, is similar to the original limestone used by Senefelder, the inventor of this printing process. This surface has good absorptivity (although sealed by boiling water), a hard surface and corrosion resistance. Because of its absorptivity, this type of plate can be used with less water thereby increasing printing quality and reducing the potential problems arising from moisture effects on the paper stock being printed.[13]

FOOTNOTES FOR APPENDIX D

[1]H. M. Cartwright, Ilford Graphic Arts Manual, vol. 2: Photolithography (London: Percy Lund, Hamphires & Co. Ltd., 1966), p. 376.

[2]Ibid., p. 380.

[3]Charles Shapiro, ed., The Lithographers Manual, fourth ed. (Pittsburgh: Graphic Arts Technical Foundation, Inc., 1970), p. 10:19.

[4]D. J. George, C. J. Walton, and W. G. Zelley, "Chemical Pretreating and Finishing," in Aluminum vol. 3: Fabrication and Finishing, ed. Kent R. Van Horn (Metal Park: American Society for Metals, 1967), p. 604.

[5]Cartwright, Photolithography, p. 380.

[6]John H. Powers, "Anodizing for the Graphic Arts Industry," TAGA Proceedings, 1970, pp. 166, 167.

[7]Albert R. Materazzi, "Anodized Aluminum Plate: Part 1 Manufacture," Graphic Arts Monthly, May 1973, p. 102.

[8]George, et al., "Chemical Pretreating and Finishing," p. 604.

[9]Powers, "Anodizing for the Graphic Arts Industry," p. 168.

[10]S. W. Dean, Jr., and J. A. Ford, "Mechanisms of Plate Wear and Failure in Anodized Aluminum Litho Plates," TAGA Proceedings, 1973, p. 210.

[11]W. C. Cochran, "Anodizing," in Aluminum vol. 3: Fabrication and Finishing, ed. Kent R. Van Horn (Metals Park: American Society for Metals, 1967), p. 663.

[12]R. J. Burnett, "Focus on Litho Plates Part 2," Printing Equipment and Materials, January 1973, p. 29.

[13]Ibid., p. 30.

APPENDIX E

MULTIPLE RANGE TEST

Multiple Range Test for Grain Coarseness

The result from the variance analysis in Table 2 shows that there is a significant differênce among the means of grain coarseness of the test plates. This analysis does not tell which grained plate is coarser. To determine this, the individual means must be compared by other statistical techniques.[1] In this paper, Duncan's Multiple Range Test was used. The detail of calculation method was explained by Rickmers and Todd.[2] The following is the calculation of the multiple range test for grain coarseness.

To run the multiple range test, the means of the individual type of grain must be arranged in rank position.

$\overline{X}_a$	$\overline{X}_c$	$\overline{X}_{ba}$	$\overline{X}_{bc}$	$\overline{X}_s$
4.830	4.855	7.435	7.730	20.190

The standard error of the means which is required to compute the shortest significant range, is $S_{\bar{X}} = S_e^2/n$. The S_e^2 is the mean square for the error in the ANOVA table (Table 2) and the n is the number of numbers used in the calculation of each mean value. In this case n equals 2, (the means shown above were obtained from two sets of plates).

The $S_{\bar{x}}$ is 0.4381.

The degrees of freedom for error in the ANOVA table were used to find the value in the Multiple Range Test Table at g = 2, g = 3, g = 4 and g = 5, where g is the number of means in a group to be compared.[3] At 0.05 level of significance*, the values obtained from the table are: for g = 2, 3.64; for g = 3, 3.74; for g = 4, 3.79; and for g = 5, 3.83. Each of these table values must then be multiplied by the standard error value of 0.4381, and the resulting SSR (Significant Studentized Range) values are:

g	2	3	4	5
SSR	1.5947	1.6385	1.6604	1.6779

See the comparison of the individual means in Table 3.

Calculation of SSR for Coating Thickness

From Table 6, the S_e^2 of coating thickness is 0.0005243. The n is 6 (each mean of coating thickness was calculated from six plates).

$$S_{\bar{x}} = 0.0005243/6$$
$$= 0.0093434$$

The degrees of freedom for error in the ANOVA table (Table 6) are 20.

---

*Level of significance is the probability of making error type I in a statistical test. Error type I is that of rejecting the null hypothesis in the statistical test when it is incorrect to do so and the null hypothesis should have been accepted.[4] The null hypothesis in this case (Grain coarseness) is - that the means of grain coarseness of the grained plates are the same.

TABLE 21. SSR VALUE FOR COATING THICKNESS

g	Table Value	SSR
2	2.95	0.0275630
3	3.10	0.0289645
4	3.18	0.0297120

Calculation of SSR for Resolution Measurement

From Table 16, the S_e^2 of resolution is 3,160.88. The n is 4 (each mean of the resolution was obtained from two plates and measured at two magnifications).

$$S_{\bar{x}} = 3,160.88/4$$
$$= 28.1109$$

The degrees of freedom for error in the ANOVA table (Table 16) are 8.

TABLE 22. SSR VALUE FOR RESOLUTION MEASUREMENT

g	Table Value	SSR
2	3.26	91.6415
3	3.39	95.6415
4	3.47	97.5448

FOOTNOTES FOR APPENDIX E

[1]Virgil L. Anderson and Robert A. McLean, Design of Experiments: A Realistic Approach vol. 5 in Statistic Textbook and Monographs Series ed. D. B. Owen et al. (New York: Marcel Dekker, Inc., 1974), p. 10.

[2]Albert D. Rickmers and Hollis N. Todd, Statistics: An Introduction (New York: McGraw-Hill Book Co., 1967). pp. 223-224.

[3]Ibid., p. 578.

[4]Ibid., p. 64.

APPENDIX F

PRINTING CHARACTERISTIC CURVE

The general method used to show the relationship between an original and its reporduction is to plot the densities of the reproduction against the densities of the original. If the curve is plotted on ordinary graph paper, it may be misleading because the eye does not respond equally to density differences in light and dark parts of pictures. Rhodes suggested converting the density to Munsell value (this unit is used in the Munsell color notation system), which corresponded more closely to the visual response.[2] He designed a special graph paper using the Munsell value scale in which the differences at the high value end of the scale were appreciably reduced. The graph paper was redesigned by Yule.[3] This special graph paper was designed in such a way that the density unit can still be used and the curve would correspond to what the eye sees in printed reproductions. The unequally spaced densities, in the graph paper, correspond to a linear scale of Munsell values.

In this study, the tint densities of the printed halftone scale (133 lines per inch of Bychrome Scale) were plotted against the per cent dot areas of the original negative film of the Bychrome scale. These per cent dot areas were obtained by converting the integrated densities of original Bychrome Scale measured by a transmission densitometer.

FOOTNOTES FOR APPENDIX F

[1]John A. C. Yule, Report Number 127 on Plotting Tone Reproduction Curves (Rochester: Graphic Arts Research Center, n.d.), p. 1.

[2]W. L. Rhodes, "Tone and Color Control in Reproduction Process," TAGA Proceedings, 1954, pp. 48-64.

[3]Yule, Report Number 127 on Plotting Tone Reproduction Curves, pp. 1-11.

APPENDIX G

INK DOT SCUM ON ALUMINUM PLATES

Ink dot scum is the thin sharp dots of ink on the non-image areas of the plates. The mechanism of this type of scum was studied by the Graphic Arts Technical Foundation.[1] It was found that the ink dot scum occurred in spots where the aluminum plate was just starting to corrode or oxidize. It did not take place on the whole surface of the plate. The areas between spots was still well desensitized.

FOOTNOTES FOR APPENDIX G

[1] Paul J. Hartsuch, Chemistry of Lithography (Pittsburgh: Graphic Arts Technical Foundation, Inc., 1961) pp. 307-308.

APPENDIX H

MATERIALS USED IN THE EXPERIMENT

Printing Plates

All test plates were obtained from the plate manufacturers:

TABLE 23. PRINTING PLATES USED IN THE EXPERIMENTS

Commercial Name	Type of Grain	Manufacturer
John Stark S-31	Anodize	Richardson Graphic Co.
-	Anodize	Azoplate Co.
Wipe-O	Brush	Litho Chemical and Supply Co.
-	Brush	Azoplate Co.
Granite Grain	Chemical	Western Litho Plate and Supply Co.
ST	Sandblast	Summer Williams, Inc.

The thickness of the plates varied from 0.005 to 0.012 inches. Only the brush grain and the sandblast grain were available in the small press size 10 X 15-3/4 inches. The other plates had to be cut and punched in the laboratory

Sensitizing Solution and Developer

These were obtained from the Litho Chemical and Supply Company

Paper

White Productolith Enamel, 8-1/2 X 11 inches, 60 and 70 lbs were used.

Ink

Offset Comsat Black from Capico Printing Ink Co., Inc. was used.

APPENDIX I

EXPERIMENTAL EQUIPMENT

Microscope

A microscope with 450 maximum magnification was used to examine the general structure of the grains. The uniformity, the presence and absence of directionality of the grains were investigated.

Sheffield Smoothchek

This instrument is generally used in a paper testing laboratory. It is designed to measure the rate of air leakage around a stationary smooth head of annular metal rings placed on a sample surface.[1] The rate of air flow indicates degree of smoothness of the sample.

Vanceometer

This instrument is the oil adsorption tester generally used in a paper testing laboratory.[2] It also measures specular gloss at 70 degrees from the vertical. The instrument consists of a projection lamp and condenser lens mounted in such a way as to cast a beam of light on a sheet surface at an angle of 20 degrees from the horizontal. The light is then reflected in a straight beam through an iris diaphragm into a photo-electric cell connected to a microammeter.

Slide Projector

A slide projector was used in measuring contact angle on each printing plate. The diagram of the optical geometry is shown in Figure 3. The projector was used as the light housing. The projection lens was placed between the printing plate and a screen, which was a piece of polar coordinate graph paper. The projector projected a magnified image of a drop of water on the plate to the screen where the contact angle was measured. As seen in Figure 3b, an empty cone was attached to the light housing in order to get a sharp image when a drop of water was placed far from the magnifying lens. Using this instrument the readings of the contact angles may vary approximately $\pm$ 3 degrees.

Reflection Densitometer

The Welch Densichron 2 reflection densitometer was used to measure sensities on press sheets. It was calibrated with a Kodak Reflection Density Guide, and the scale was zeroed with unprinted paper. Calibrations were done periodically throughout the experiments.

Press

All the experiments on the press were done on an ATF Chief 15.

FOOTNOTES FOR APPENDIX I

[1] Robert F. Reed, *What the Printer Should Know About Paper* (Pittsburgh: Graphic Arts Technical Foundation, Inc., 1970), p. 166.

[2] *Ibid.*, p. 159.

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